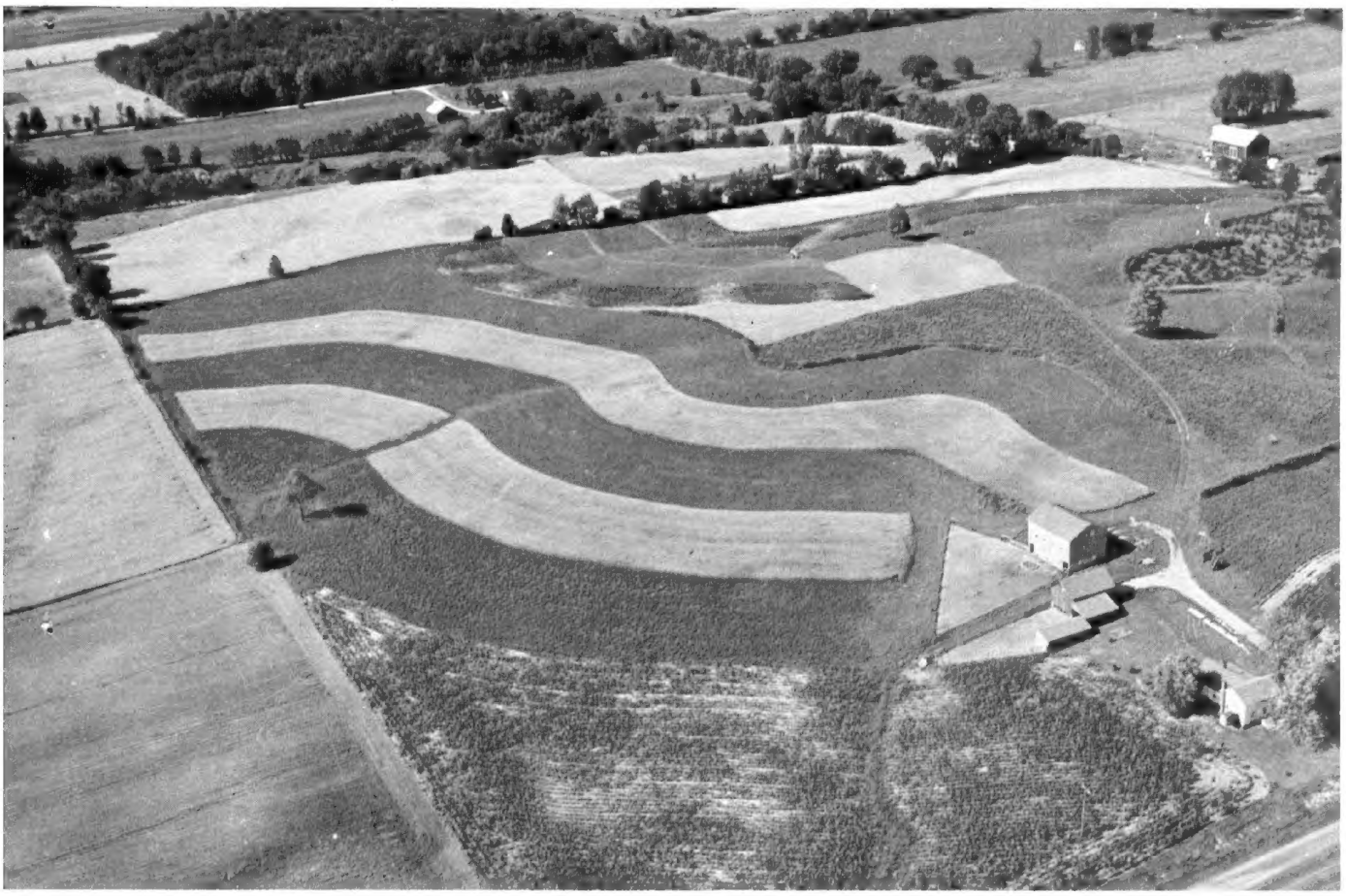
SOIL SURVEY OF

Ottawa County, Michigan



United States Department of Agriculture
Soil Conservation Service
In cooperation with
Michigan Agricultural Experiment Station

Issued December 1972

Major fieldwork for this soil survey was completed in 1966. Soil names and descriptions were approved in 1967. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1968. This survey was made cooperatively by the Soil Conservation Service and the Michigan Agricultural Experiment Station. It is part of the technical assistance furnished to the West Ottawa County Soil Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Ottawa County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification and woodland suitability classification of each. It also shows on what page each soil is described and on what pages the capability unit and the woodland suitability group are described.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and woodland suitability groups.

Foresters and others can refer to the section "Woodland," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife habitat in the section "Wildlife."

Community planners and others can find, in the section "Soil Properties in Relation to Town and Country Planning," information significant in various aspects of town and country planning.

Engineers and builders can find, under the heading "Engineering Uses of the Soils," tables that contain estimates of specified soil properties and interpretations of these soil properties as they affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils.

Newcomers to the county may be especially interested in the "General Soil Map," where broad patterns of soils are described, and in the general information about the county given at the beginning and the end of this publication.

Cover: **Stripcropping and grassed waterways in an area of Nester soils.**

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SOIL SURVEY OF OTTAWA COUNTY, MICHIGAN

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UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE MICHIGAN AGRICULTURAL EXPERIMENT STATION

OTTAWA COUNTY is situated in the southwestern part of Michigan, bordering Lake Michigan (fig. 1). Its eastern boundary is about 30 miles from north to south, the western shoreline is about 24 miles long, and the east-west boundaries are about 22 miles long. The area is approximately 564 square miles. Grand Haven, the county seat, is in the northwestern part of the county, at the mouth of the Grand River.

About half of the county is in farms. Corn, wheat, oats, hay, and fruit are the major crops. Dairy products are also important. Large areas are wooded.

Figure 1.—**Location of Ottawa County in Michigan.**

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Ottawa County, where they are located, and how they can be used. The soil scientsits went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the underlying material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied and compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey (*8*)[1].

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Allendale and Nester, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in the texture of their surface layer and in slope, stoniness, or some other characteristic that affects the use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Nester loam, 2 to 6 percent slopes, is one of several phases within the Nester series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately.

[1] Italic numbers in parentheses refer to Literature Cited, p. 137.

The soil map at the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Ottawa County: the soil complex and the undifferentiated group.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately at the scale used for the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Adrian-Houghton mucks is an example.

An undifferentiated group is made up of areas of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Croswell and Au Gres sands, 0 to 6 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Blown-out land, 0 to 6 percent slopes, is a land type in Ottawa County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Ottawa County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. It is useful in watershed management, woodland management, and community development. It is not suitable for planning the management of a farm or field or for selecting an exact location for a road or building, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their use.

The 12 soil associations in Ottawa County are described in the following pages.

1. Rubicon-Blown-out land-Deer Park association

Level to steep, well-drained, sandy soils of the dunes and plains

Association 1 extends the entire length of the western border of Ottawa County, along Lake Michigan. It is made up of steep young sand dunes next to the lake and stabilized older dunes and level to sloping sand plains inland from the lake. In acreage it totals about 15 percent of the county.

Rubicon soils (fig. 2) are on the stabilized dunes and the plains and make up about 45 percent of the association. They are older than Deer Park soils and have more distinct horizons and are more acid. Deer Park soils occupy the steep dunes next to the lake and make up about 15 percent of the association. They are young soils and have faint horizons. Blown-out land makes up 25 percent of the association. It consists of Rubicon and Deer Park soils from which wind has removed both the surface and subsurface layers; the loose sand substratum is at the surface in most places, and active blowouts are common. The remaining 15 percent of the association is made up mainly of moderately well drained Croswell soils, somewhat poorly drained Au Gres soils, and poorly drained to very poorly drained Granby soils.

All the major soils of this association have a very low available water capacity and very low natural fertility. Unless irrigated, they have severe limitations for farming. Rubicon and Deer Park soils support a mature mixed forest of conifers and hardwoods, including sugar maple, red oak, hemlock, and white pine. Stabilizing Blown-out land is a major problem (fig. 3).

Limitations for community development and recreational uses are no more than slight. The soils are good material for foundations for buildings, highways, and other structures. Scenic views and attractive settings for homes are plentiful. Many landowners are developing wildlife areas and recreational facilities. Churches and other groups have established camps along the lakeshore. Reforested areas belonging to schools and townships are

Figure 2.—**A Rubicon sand in association 1. Scotch pine and red pine have been planted.**

used as outdoor classrooms and for recreation and are also sources of income.

2. *Rubicon-Granby-Croswell-Au Gres association*

Level and gently sloping, well-drained to very poorly drained, sandy soils of the lake plains and outwash plains

Association 2 extends from the central part of the county to the northwestern part. It consists of sandy plains on which are scattered long, low, narrow, dunelike ridges. In acreage it totals about 20 percent of the county.

Rubicon soils occupy the ridges and the higher parts of the plains. These well-drained soils make up about 25 percent of the association. Granby soils, which are poorly drained or very poorly drained, are in drainageways and on slightly depressed broad flats. They make up about 25 percent of the association. Croswell soils, which are moderately well drained, and Au Gres soils, which are somewhat poorly drained, are on slightly lower parts of the plains and commonly occur together. They make up about 25 percent of the association. The remaining 25 percent is made up largely of somewhat poorly drained Saugatuck soils, well drained and moderately well drained Montcalm soils, somewhat poorly drained Allendale soils, and poorly drained fine sands.

The major soils of this association are severly limited for farming by droughtiness, low fertility, and a hazard of soil blowing. Much of the acreage is idle. Only small areas are farmed. Small fruits and vegetables are grown, usually under irrigation. Christmas trees and other forest products are suitable crops. Christmas tree plantations of 5 to more than 160 acres are common. Scotch pine is the species most commonly planted for Christmas trees (fig. 4). Other areas that have been reforested with pine are managed for pulpwood and timber. The mixture of small farms, idle fields, and woods creates a favorable environment for wildlife.

Rubicon and Croswell soils have few limitations for community development, except for droughtiness, which makes it difficult to establish lawns and shrubbery. Au Gres soils are severely limited by excessive wetness and instability.

3. *Granby-Au Gres-Saugatuck association*

Nearly level and gently sloping, very poorly drained to somewhat poorly drained, sandy soils of the lake plains.

Association 3 occurs as one large area in the central and west-central parts of the county and one small area near the north-central boundary. Generally, the nearly level plains are broken by only minor dips and swells, but low, narrow ridges occur locally. In acreage this association totals about 12 percent of the county.

Granby soils, the darkest colored of the major soils, occupy the broad, nearly level parts of the plains and make up about 50 percent of the association. They have a high water table and poor or very poor drainage. Au Gres soils, which are somewhat poorly drained, occupy low swells and ridges and make up about 25 percent of the association. Saugatuck soils have a cemented pan in the subsoil and are poorly drained or somewhat poorly drained. They are at elevations a few inches to a foot or two higher than Granby soils, and they also occur as slight depressions within the larger areas of Au Gres soils. Saugatuck soils make up about 15 percent of the association. The remaining 10 percent of the association is made up mainly of moderately well drained Croswell soils; of

Figure 3.—Blown-out land, in association 1, stabilized with rows of beachgrass and wood pilings in 13-foot squares.

areas, mainly in the southern part of Blendon Township, in which the soils have a clayey substratum at a depth of 2 to 5 feet; and of areas in which fine-textured lake-laid material occurs in the subsoil and substratum.

The soils in this association are severely limited for farming by a low available water capacity, low fertility, and a severe hazard of soil blowing. Special crops, including blueberries and truck crops, are grown on selected sites for which supplemental irrigation is available. The low wet areas are subject to early frost, and many are difficult to drain because they lack outlets. Trees grow slowly and are usually of low quality. Reforestation is generally limited to Christmas tree plantations on Au Gres soils. Wildlife that requires an open-land habitat is abundant.

Limitations for community development are severe. The high water table interferes with the functioning of sewage-disposal systems, and shallow wells in these porous soils are likely to be polluted by sewage effluent. Most of the homes and other buildings within the association are located on the highest parts of the landscape.

4. Nester-Kawkawlin-Sims association

Gently sloping to rolling, well-drained to poorly drained, loamy soils of the uplands

Association 4 occurs in the east-central and northeastern parts of the county. The landscape is one of rolling uplands. All the major soils developed in glacial drift of clay loam texture. They differ mainly in degree of drainage. In acreage this association totals 12 percent of the county.

Nester soils, which are well drained or moderately well drained, occupy the higher parts of the landscape and make up about 55 percent of the association. The somewhat poorly drained Kawkawlin soils and the poorly drained Sims soils occupy depressions, the lower part of slopes, and basins between slopes. Kawkawlin soils make up about 15 percent of the association, and Sims soils, about 10 percent. The remaining 20 percent of the acreage is made up mainly of well drained and moderately well drained Ubly soils, somewhat poorly drained Belding soils, and poorly drained Breckenridge soils.

The major soils of this association have few limitations for farming. Erosion is a hazard, and the Kawkawlin and Sims soils need random tile drainage. Dairying is the chief livestock enterprise, but some beef cattle are raised. Corn, small grain, and hay are common crops. Good orchard sites are common in the area east of the main drainageway in Chester and Wright Townships. Apples are the leading orchard crop. Peaches, pears (fig. 5), cherries, and plums are grown also. Woodlots of 5 to 15 acres are common. Sugar maple, red oak, beech, and aspen are the principal species in the woodlots; some white pine is also included. The rolling terrain and the mixture of

Figure 4.—Scotch pines, tagged and ready to be harvested for Christmas trees; soil is an Au Gres loamy sand, in association 2.

cropland, orchards, and woodland provide cover and food for birds and animals that need an open-land habitat.

Moderately slow permeability and a hazard of frost heave are severe limitations for community development. Kawkawlin and Sims soils have the additional limitation of a fluctuating high water table.

5. *Richter-Gilford-Gladwin association*

Nearly level and gently sloping, somewhat poorly drained to very poorly drained, sandy and loamy soils of glacial drainageways

Association 5 occupies glacial drainageways in the northeastern part of the county. The landscape is one of nearly level plains intermixed with gently sloping areas. In acreage this association totals about 4 percent of the county.

Richter soils are stratified sandy loams; they are nearly level or gently sloping and are somewhat poorly drained. They make up about 25 percent of the association. Gilford soils are predominantly sandy loam and are underlain with limy sand and gravel; they are nearly level and are poorly drained or very poorly drained. They make up about 20 percent of the association. Gladwin soils are loamy sand or sandy loam and are underlain with sand and gravel; they are nearly level and are somewhat poorly drained. They make up about 20 percent of the association. The remaining 35 percent of the acreage is made up of somewhat poorly drained Matherton soils, well-drained Chelsea and Newaygo soils, poorly drained Lacota and Tonkey soils, somewhat poorly drained Au Gres soils, and poorly drained to very poorly drained Granby soils.

The major soils of this association need artificial drainage but otherwise have no serious limitations for farming. Corn, small grain, and hay are the common crops. Beans, pickling cucumbers, and melons are also grown. Many fields are not drained well enough to be suitable for cultivated crops and are used only for hay or pasture. Other areas are idle. Woodlots are common, but trees generally grow slowly and are of poor quality. Maple, aspen, elm, and ash are among the common species. Many elm trees are dead or diseased.

Limitations for community development are severe. Unfavorable texture and alternating excessive wetness and droughtiness are among the limiting characteristics.

6. *Mancelona-Nester-Belding-Iosco association*

Gently sloping to hilly, well-drained to somewhat poorly drained, sandy and loamy soils of the uplands

Association 6 occupies one large area in the northeastern part of the county and one small area in the north-central part. The slopes are complex. In acreage this association totals 10 percent of the county.

Both Mancelona and Nester soils are well drained or moderately well drained. Mancelona soils make up about 25 percent of the association, and Nester soils about 20 percent. Belding and Iosco soils occur on the lower parts of slopes and in depressions and are somewhat poorly drained. Together they make up about 25 percent of the association. The remaining 30 percent is made up of well

Figure 5.—Young pear orchard on Nester soils, in association 4.

drained or moderately well drained Montcalm soils and somewhat poorly drained Richter, Au Gres, and Blount soils.

Complex soil patterns and complex slopes impose some limitations for farming. Erosion is a hazard. Some areas need artificial drainage. General farming is the predominant land use. Corn, small grain, hay, and pickling cucumbers are the main crops. Both dairy cattle and beef cattle are raised. A few sites in the association are suitable for the production of fruit. Woodlots of 5 to 40 acres are common. Maple, oak, hickory, aspen, and beech are the principal species in the woodlots. In wet depressions dead and diseased elms predominate. Some areas of sandy soils have been reforested with pine. Food and cover for wildlife are abundant, and both open-land and woodland wildlife are plentiful.

The most easterly part of this association, mainly in Tallmadge Township, is being converted to suburban use as a result of the growth of the city of Grand Rapids. The area offers scenic views and suitable locations for homes. Some of the soils have only slight limitations for community development, but others have severe limitations. Careful investigation and planning are needed to avoid such troubles as wet basements, uneven settling, cracked foundations, and failure of sewage-disposal systems.

7. Sloan-Adrian-Houghton association

Level, poorly drained, bottom-land soils and organic soils

Association 7 extends from Jenison, on the eastern border of the county, southwestward to Zeeland. The area is an old glacial drainageway and is now occupied by Black Creek. In acreage this association totals 4 percent of the county.

Sloan soils are on bottom lands and make up about 30 percent of the association. Adrain and Houghton soils are in depressions. Adrian soils consist of 12 to 42 inches of organic material over sand, and Houghton soils of more than 42 inches of organic material. Together they make up about 40 percent of the association. The remaining 30 percent is made up mainly of very poorly drained Carlisle and Linwood soils, poorly drained Wallkill soils, and somewhat poorly drained Shoals soils.

The soils of this association are limited for farming by a flood hazard, excessive wetness, low fertility, and a hazard of soil blowing. Nevertheless, intensive farming is common. Artificial drainage is essential if cultivated crops are to be grown. Adrain and Houghton soils are used

mainly for specialty farming; celery, onions, and carrots are common crops. They are also used to some extent for general farming. Sloan soils are used for general farming. Some undrained areas are used only for hay and pasture. Woodlots are very few on the soils of this association. Food for wetland wildlife is generally plentiful.

Limitations for community development are severe. The soils are unstable, and the high water table interferes with the functioning of septic-tank systems and hinders the construction of basements.

8. *Chelsea-Mancelona-Montcalm association*

Level and gently sloping, well drained and moderately well drained, gravelly and sandy soils of outwash plains and terraces

Association 8 occurs as two small areas in the east-central part of the county. The topography is dominantly level and gently sloping, but small areas next to drainageways have short, steep slopes. In acreage this association totals 3 percent of the county.

Chelsea soils, which are well drained, make up about 30 percent of the association; they occupy the higher parts of the plains. These soils have thin layers of loamy sand below a depth of 42 inches. Mancelona soils, which are well drained or moderately well drained, make up about 25 percent of the association. They are on slightly lower parts of the plains and terraces and on short slopes next to drainageways. They are underlain with sand and gravel at a depth of 18 to 40 inches. Montcalm soils, which are well drained or moderately well drained, make up about 25 percent of the association. They occur with Chelsea soils on the higher parts of the plains and are similar to Chelsea soils but finer textured below a depth of 42 inches. The remaining 20 percent of the acreage is made up mainly of somewhat poorly drained Gladwin and Matherton soils, poorly drained Lacota soils, and poorly drained or very poorly drained Gilford soils.

The major soils of this association are limited for farming by low fertility, a shortage of moisture, and a hazard of soil blowing. General farming and some livestock farming are practiced. Most of the common crops are grown. Limitations for growing trees are slight. Small woodlots are scattered throughout the association, and some pine plantations have been established, but the production of wood crops is not a major land use. Wildlife that requires an open-land habitat is abundant.

Limitations for community development are slight. Farmland is rapidly being converted to residential and commercial uses, as a result of the growth of the city of Grand Rapids. Many residences have been built, and homesites of between 1 acre and 20 acres are numerous.

Gravel pits that yield material suitable for use in highway building and other construction are common.

9. *Blount-Morley-Kibbie association*

Level and gently sloping, well-drained to somewhat poorly drained, loamy soils of uplands

Association 9 occupies till plains in the southeastern part of the county. Short, steep breaks to drainageways are the only significant variations in the gradual, fairly long slopes. In acreage this association totals about 8 percent of the county.

Blount soils are level or gently sloping and are somewhat poorly drained. They make up about 45 percent of the association. Morley soils are gently sloping to steep and are well drained or moderately well drained. They occur on the slightly higher parts of the landscape and on the short, steep breaks. They make up about 20 percent of the association. Kibbie soils are level and somewhat poorly drained. They make up about 10 percent of the association. The remaining 25 percent of the acreage is made up mainly of well drained or moderately well drained Owosso soils, well-drained Tuscola soils, and poorly drained Sims soils. Sims soils occupy depressions.

Because the slopes are fairly long, there is some hazard of erosion. Structure and tilth deteriorate if the soils are worked when wet. Blount soils and Kibbie soils need artificial drainage. General farming is the major land use. Small woodlots containing a mixture of hardwoods are common. Many of the woodlots are on breaks to drainageways. Others are in poorly drained depressions; in these, the trees are generally of low quality, and many dead and diseased elms are included. Wildlife that requires an open-land habitat is abundant.

Limitations for community development are moderate to severe. Moderately slow permeability, a seasonal high water table, and susceptibility of frost heave are among the unfavorable characteristics.

10. *Miami-Hillsdale-Spinks association*

Rolling and hilly, well-drained, loamy and sandy soils of the uplands

Association 10 is in the southeastern corner of the county. The landscape is characterized by short, broken slopes and wet pockets and depressions. In acreage this association totals 3 percent of the county.

Miami and Hillsdale soils are loamy, and Spinks soils are sandy. Miami soils make up about 35 percent of the association, Hillsdale soils about 25 percent, and Spinks soils about 20 percent. The remaining 20 percent is made up mainly of somewhat poorly drained Metamora and Conover soils, poorly drained Sims and Washtenaw soils, and very poorly drained Edwards and Cohoctah soils. These minor soils occupy the pockets and depressions and the lower parts of slopes.

The erosion hazard is the main limitation for farming. Dairying and beef farming are the principal land uses. Miami and Hillsdale soils are well suited to crops but need careful management if cultivated. Woodlots are numerous. The trees are mainly hardwoods, including maple, beech, oak, hickory, and some largetooth aspen. Food and cover for all types of wildlife are abundant.

The stronger slopes of this association have some limitations for intensive uses, but otherwise limitations for community development are slight.

11. *Bowers-Hettinger-Nester association*

Nearly level to gently sloping, well-drained to poorly drained, loamy soils of the lake plains

Association 11 is in the north-central part of the county. The nearly level to gentle slopes are interrupted by breaks to drainageways. In acreage this association totals 4 percent of the county.

Bowers soils, which are nearly level to gently sloping and are somewhat poorly drained, make up about 40 percent of the association. Hettinger soils, which are in depres-

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sions and drainageways and are poorly drained, make up about 20 percent of the association. Nester soils are next to drainageways, have short, irregular slopes, and are well drained to moderately well drained; they make up about 10 percent of the association. The remaining 30 percent of the acreage is made up mainly of somewhat poorly drained Kawkawlin, Belding, and Allendale soils, poorly drained Brevort and Pinconning soils, well-drained Rubicon soils, and well drained or moderately well drained Montcalm soils.

Bowers and Hettinger soils need artificial drainage, but otherwise the soils of this association are suitable for farming. Many areas are in livestock farms. Partly because of inadequate drainage, much of the acreage is now in pasture or hay. Some is idle. Woodlots of 5 to 40 acres occur on all the soils of the association. Most are in drainageways or on breaks to drainageways. On the Bowers and Hettinger soils, the stands generally consist of slow-growing, low-quality hardwoods, including red maple, silver maple, cottonwood, largetooth aspen, elm, and ash. Many elm trees are dead or diseased. The mixture of cropland, pasture, and woodland provides food and shelter for wildlife that needs an open-land habitat.

Limitations for community development are severe. A fluctuating water table, unfavorable texture, and slow permeability are among the limiting characteristics.

12. Kawkawlin association

Gently sloping, somewhat poorly drained, loamy soils of the till plains

Association 12 is a low-lying area in the south-central part of the county. In acreage it totals about 5 percent of the county.

Kawkawlin soils make up about 55 percent of the association. The rest is made up mainly of poorly drained Sims, Breckenridge, and Brevort soils, well drained or moderately well drained Menominee, Ubly, and Nester soils, and well-drained Chelsea soils. No single one of these minor soils makes up a significant percentage of the acreage.

Kawkawlin soils have few limitations for farming. They are well suited to the common crops if drained of excess water. Livestock farming is the principal land use. Corn, small grain, and hay are the common crops. Fields that are inadequately drained are used for hay or pasture. Woodlots are not so common nor so large as in the other associations. Maple, aspen, birch, and elm are the common species. Woodlots in the wettest areas contain mainly slow-growing, low-quality red maple, silver maple, cottonwood, elm, and ash. Many elm trees are dead or diseased. Wildlife that requires an open-land habitat is abundant.

Kawkawlin soils and most of the minor soils have some properties unfavorable for community development. Among these are excessive wetness, a moderate shrink-swell potential, and moderately slow permeability.

Descriptions of the Soils

In this section the soil series and mapping units of Ottawa County are described. The acreage and proportionate extent of each mapping unit are given in table 1.

The procedure is to describe first a soil series and then the mapping units in that series. To get full information on any given mapping unit, one needs to read the description of the series as well as the description of the mapping unit.

Each series includes two descriptions of the same typical profile of a soil of the series. The first is a brief description, in paragraph form, which many readers will find gives as much information as they need. The second is a longer, more detailed description that soil scientists, engineers, and others can use as a basis for technical interpretations.

As explained in the section "How This Survey Was Made," some mapping units are miscellaneous land types rather than soils of any given series. The Blown-out land units are examples. Such mapping units are described in this section, along with the soil series and the soil units.

In parentheses following the name of each mapping unit is a symbol made up of capital and small letters and, in some cases, a figure. This symbol identifies the mapping unit on the detailed soil map, which is at the back of this publication. In parentheses at the end of each soil description are the symbols that identify the capability unit, the Michigan management group (*5*), and the woodland suitability group in which the mapping unit has been placed. The "Guide to Mapping Units," at the back of this publication next to the detailed soil map, gives the map symbols and names of all the mapping units, in alphabetical order; the number of the page on which each unit is described; the symbol for the capability unit, the Michigan management group, and the woodland suitability group for each mapping unit; and the number of the page on which the capability unit and the woodland suitability group are described.

Technical terms used in describing the soils are defined in the Glossary.

Adrian Series

The Adrian series consists of poorly drained, fibrous organic deposits that are 12 to 42 inches thick over sand. These soils occur on bottom lands, in shallow depressions on the sandy plains, and in depressions on the uplands.

In a typical profile, the surface layer consists of black muck and is about 14 inches thick. Below the muck is about 6 inches of dark reddish-brown, finely divided, fibrous peat. The underlying material consists of a 4-inch layer of very dark gray loamy sand over 36 inches of grayish-brown and light brownish-gray sand.

Adrian soils are low in fertility and moderate in available water capacity. They are rapidly permeable. The organic material is susceptible to decomposition and settling and to soil blowing. Frost damage to crops is a hazard.

Drained areas of these soils are suitable for crops. Undrained areas are suitable for pasture or for woods. The native vegetation consists of grass, shrubs, reeds, and sedges.

Typical profile of Adrian muck, cultivated, located in the NW¼NE¼NW¼ sec. 30, T. 5 N., R. 14 W. (Zeeland Township):

1—0 to 14 inches, black (10YR 2/1) muck; fine, granular structure; friable; neutral; clear, wavy boundary.
2—14 to 20 inches, dark reddish-brown (5YR 3/2) fibrous peat; weak, thick, platy structure; friable; neutral; clear, wavy boundary.

TABLE 1.—*Approximate acreage and proportionate extent of soils*

Soil	Acres	Percent
Adrian muck	1, 655	0. 4
Adrian-Houghton mucks	4, 176	1. 2
Algansee loamy sand	633	. 2
Allendale sandy loam, 0 to 4 percent slopes	1, 453	. 4
Au Gres loamy sand, 0 to 6 percent slopes	2, 159	. 6
Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes	1, 022	. 3
Au Gres-Saugatuck sands, 0 to 6 percent slopes	18, 022	5. 0
Belding sandy loam, 0 to 2 percent slopes	1, 163	. 3
Belding sandy loam, 2 to 6 percent slopes	3, 030	. 8
Blount loam, 0 to 2 percent slopes	3, 486	1. 0
Blount loam, 2 to 6 percent slopes	7, 344	2. 0
Blown-out land, 0 to 6 percent slopes	1, 540	. 4
Blown-out land, 6 to 50 percent slopes	15, 556	4. 3
Bowers loam, 0 to 2 percent slopes	937	. 2
Bowers loam, 2 to 6 percent slopes	3, 681	1. 0
Boyer loamy sand, 0 to 2 percent slopes	2, 732	. 8
Boyer loamy sand, 2 to 6 percent slopes	696	. 2
Boyer loamy sand, 6 to 12 percent slopes	604	. 2
Breckenridge sandy loam	604	. 2
Brevort sandy loam	680	. 2
Bruce loam	529	. 1
Carlisle muck	3, 846	1. 1
Ceresco loam	1, 989	. 5
Chelsea loamy sand, 0 to 6 percent slopes	5, 867	1. 6
Chelsea loamy sand, 6 to 12 percent slopes	302	. 1
Chelsea complex, 0 to 6 percent slopes	6, 560	1. 8
Cohoctah loam	2, 337	. 6
Conover loam, 2 to 6 percent slopes	664	. 2
Croswell sand, 0 to 6 percent slopes	3, 001	. 8
Croswell and Au Gres sands, 0 to 6 percent slopes	18, 080	5. 0
Deer Park sand, 0 to 6 percent slopes	961	. 3
Deer Park sand, 6 to 18 percent slopes	2, 836	. 8
Deer Park sand, 18 to 45 percent slopes	3, 740	1. 0
Edwards muck	636	. 2
Fox sandy loam, 0 to 6 percent slopes	398	. 1
Gilford sandy loam	3, 213	. 9
Gladwin sandy loam, 0 to 2 percent slopes	2, 822	. 8
Gladwin sandy loam, 2 to 6 percent slopes	855	. 2
Glendora sandy loam	1, 902	. 5
Granby loamy sand	45, 201	12. 6
Granby fine sandy loam	7, 733	2. 1
Gravel pits	950	. 3
Hettinger loam	2, 233	. 6
Hillsdale sandy loam, 2 to 6 percent slopes	909	. 3
Hillsdale sandy loam, 6 to 12 percent slopes	721	. 2
Iosco loamy sand, 0 to 4 percent slopes	2, 075	. 6
Iosco and Allendale loamy sands, 0 to 4 percent slopes	3, 400	. 9
Iosco-Belding complex, 2 to 6 percent slopes	1, 575	. 4
Kalkaska sand, 0 to 12 percent slopes	159	(1)
Kawkawlin loam, 0 to 2 percent slopes	4, 481	1. 2
Kawkawlin loam, 2 to 6 percent slopes	14, 185	3. 9
Kibbie loam, 0 to 2 percent slopes	1, 122	. 3
Kibbie loam, 2 to 6 percent slopes	907	. 2
Lacota silt loam	912	. 2
Lake beaches	303	. 1
Linwood muck	137	(1)
Made land	706	. 2
Mancelona loamy sand, 0 to 2 percent slopes	4, 974	1. 4
Mancelona loamy sand, 2 to 6 percent slopes	2, 940	. 8
Mancelona loamy sand, 6 to 12 percent slopes	514	. 1
Marsh	1, 695	. 5
Matherton loam, 0 to 2 percent slopes	1, 650	. 5
Menominee loamy sand, 2 to 6 percent slopes	990	. 3
Menominee loamy sand, 6 to 12 percent slopes	232	. 1
Metamora sandy loam, 0 to 2 percent slopes	824	. 2
Metamora sandy loam, 2 to 6 percent slopes	713	. 2
Miami loam, 2 to 6 percent slopes	1, 210	0. 3
Miami loam, 6 to 12 percent slopes	824	. 2
Miami loam, 12 to 18 percent slopes	284	. 1
Miami loam, 18 to 45 percent slopes	309	. 1
Montcalm loamy sand, 0 to 2 percent slopes	1, 416	. 4
Montcalm loamy sand, 2 to 6 percent slopes	3, 649	1. 0
Montcalm loamy sand, 6 to 12 percent slopes	1, 176	. 3
Morley loam, 2 to 6 percent slopes	2, 681	. 7
Morley loam, 6 to 12 percent slopes, eroded	2, 111	. 6
Morley loam, 18 to 25 percent slopes, eroded	334	. 1
Morley clay loam, 12 to 18 percent slopes, severely eroded	367	. 1
Morley clay loam, 25 to 45 percent slopes, severely eroded	1, 504	. 4
Nester loam, 2 to 6 percent slopes	20, 862	5. 8
Nester loam, 6 to 12 percent slopes	6, 973	2. 0
Nester loam, 12 to 18 percent slopes	683	. 2
Nester loam, 18 to 25 percent slopes	547	. 1
Nester loam, 25 to 45 percent slopes	2, 523	. 7
Nester clay loam, 6 to 12 percent slopes, severely eroded	582	. 2
Nester clay loam, 12 to 18 percent slopes, severely eroded	800	. 2
Nester clay loam, 18 to 25 percent slopes, severely eroded	177	. 1
Nester clay loam, 25 to 45 percent slopes, severely eroded	946	. 3
Newaygo sandy loam, 0 to 6 percent slopes	466	. 1
Oshtemo sandy loam, 0 to 2 percent slopes	1, 086	. 3
Oshtemo sandy loam, 2 to 6 percent slopes	797	. 2
Oshtemo sandy loam, 6 to 12 percent slopes	300	. 1
Oshtemo sandy loam, 12 to 18 percent slopes	386	. 1
Owosso sandy loam, 2 to 6 percent slopes	792	. 2
Pinconning loamy sand	1, 288	. 4
Pinconning and Breckenridge sandy loams	1, 808	. 5
Richter sandy loam, 0 to 2 percent slopes	3, 346	. 9
Richter sandy loam. 2 to 6 percent slopes	819	. 3
Rubicon sand, 0 to 6 percent slopes	38, 709	10. 8
Rubicon sand, 6 to 18 percent slopes	1, 823	. 5
Rubicon sand, 18 to 45 percent slopes	2, 116	. 6
Sand pits	274	. 1
Selkirk loam, 0 to 2 percent slopes	191	. 1
Selkirk loam, 2 to 6 percent slopes	527	. 1
Shoals loam	2, 088	. 6
Sims loam	3, 848	1. 1
Sloan loam	4, 348	1. 2
Spinks loamy sand, 0 to 2 percent slopes	194	. 1
Spinks loamy sand, 2 to 6 percent slopes	337	. 1
Spinks loamy sand, 6 to 12 percent slopes	394	. 1
Spinks and Montcalm loamy sands, 12 to 18 percent slopes	453	. 1
Spinks and Montcalm loamy sands, 18 to 25 percent slopes	334	. 1
Spinks and Montcalm loamy sands, 25 to 45 percent slopes	353	. 1
Toledo silty clay loam	807	. 2
Tonkey sandy loam	1, 817	. 5
Tuscola fine sandy loam, 2 to 6 percent slopes	285	. 1
Ubly sandy loam, 0 to 2 percent slopes	475	. 1
Ubly sandy loam, 2 to 6 percent slopes	2, 144	. 6
Ubly sandy loam, 6 to 12 percent slopes	456	. 1
Wallkill silt loam	851	. 2
Warners muck	318	. 1
Wasepi sandy loam, 0 to 2 percent slopes	1, 220	. 4
Washtenaw loam	619	. 2
Wind eroded land, sloping	981	. 3
Total	360, 960	100. 0

[1] Less than 0.05 percent.

IIC1g—20 to 24 inches, very dark gray (10YR 3/1) loamy sand; massive; friable; neutral; abrupt, wavy boundary.
IIC2—24 to 32 inches, grayish-brown (10YR 5/2) sand; few, medium, distinct, dark-gray (10YR 4/1) mottles and many, medium, distinct, light yellowish-brown (10YR 6/3) mottles; single grain; loose; mildly alkaline; gradual, wavy boundary.
IIC3—32 to 60 inches, light brownish-gray (10YR 6/2) sand; many, medium, faint, pale-brown (10YR 6/3) mottles and few, fine, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; moderately alkaline.

The thickness of the two organic layers combined ranges from 12 to 42 inches. The reaction of the organic material ranges from strongly acid to neutral.

In the muck layer, the organic material is moderately well to well decomposed; in the peat layer, it is well decomposed to practically undecomposed. In color, the peat ranges from dark reddish brown (5YR 3/2) to dark yellowish brown (10YR 3/4).

The texture of the IIC horizon is sand or loamy sand but predominantly sand. In some places the IIC1g horizon is lacking. Mottling is very faint or lacking in some areas.

Adrian soils are similar to Carlisle and Houghton soils, but in both Carlisle and Houghton soils, the organic layers are more than 42 inches thick. Adrian soils occur near Grandby soils, which do not have organic layers.

Adrian muck (0 to 2 percent slopes) (Ad).—This soil is scattered throughout the county. It occupies bottom lands, shallow depressions on the sandy plains, and depressions on the uplands. It is associated with and in some places intermixed with Carlisle and Houghton soils, which are deeper organic soils, and Granby soils, which are wet mineral soils.

In some areas of Adrian muck, mainly those on bottom lands, the profile consists of alternate layers of organic material and sand. In other places there are wood fragments in the organic material. Included in mapping were small areas of Granby soils and areas where the slope is between 2 and 6 percent.

Fertility is low, and the available water capacity is moderate. Natural drainage is poor, and installing artificial drainage facilities is difficult. Soil blowing is a hazard in the dry months of summer.

Many areas of this soil have been cleared and drained and are now cultivated. The larger areas are used for celery, onions, carrots, and other special crops; others are used for corn and small grain. Special mixtures of fertilizer are needed for most crops. Undrained areas are used for pasture or left idle. (Capability unit IVw–5 (M/4c); woodland suitability group U)

Adrian-Houghton mucks (0 to 2 percent slopes) (Ah).—In some places Adrian and Houghton soils occur together in such intricate patterns that neither soil can be shown separately on the soil map. This complex is on sandy plains, in depressions, and in drainageways.

Most areas of this complex are 60 percent Adrian muck, 25 percent Houghton muck, and 15 percent other soils. In the Adrian soil, the organic deposit is 12 to 42 inches thick; in the Houghton soil, it is more than 42 inches thick. In some areas of Adrian muck, thin layers of organic material occur within the sand substratum. Included in mapping were small spots of Granby soils.

Fertility is low, and the available water capacity is moderate to very high. Natural drainage is poor, and in many areas it is difficult to install and maintain artificial drainage systems. Soil blowing and frost damage are hazards.

Many areas of this complex have been cleared and drained and are now cultivated. Some of these areas are used for celery, onions, carrots, and other special crops; others are used for corn and small grain. Special mixtures of fertilizer are needed for most crops. Undrained areas are used for pasture or for woods or are left idle. Some areas now idle have been cropped continuously and have lost organic material through decomposition, settling, and erosion. (Capability unit IVw–5 (Adrian—M/4c, Houghton—Mc); woodland suitability group U)

Algansee Series

The Algansee series consists of somewhat poorly drained soils on flood plains.

In a typical profile, the surface layer consists of black loamy sand and is about 10 inches thick. Below this are layers of light yellowish-brown, grayish-brown, very dark gray, and brown, very friable to loose sand.

Algansee soils are low in fertility and in available water capacity and are rapidly permeable. They are subject to flooding and susceptible to soil blowing.

Most areas of these soils are still wooded. The native vegetation is a mixture of hardwoods, including red maple, elm, swamp white oak, and aspen. A few areas have been cleared and are used as native pasture.

Typical profile of Algansee loamy sand, undisturbed, located in the SW¼SE¼NW¼ sec. 17, T. 7 N., R. 13 W. (Tallmadge Township):

A1—0 to 10 inches, black (10YR 2/1) loamy sand; weak, medium, granular structure; friable; medium acid; clear, smooth boundary.
C1—10 to 13 inches, light yellowish-brown (10YR 6/4) sand; many, coarse, distinct, very dark gray (10YR 3/1) mottles and few, fine, distinct, yellowish-red (5YR 5/8) mottles; single grain; loose; medium acid; gradual, wavy boundary.
C2—13 to 31 inches, grayish-brown (10YR 5/2) sand; few, fine, distinct, yellowish-brown (10YR 5/8) mottles; single grain; loose; very dark grayish-brown (10YR 3/2) vertical streaks, becoming fewer with depth; medium acid; abrupt, smooth boundary.
C3g—31 to 38 inches, very dark gray (10YR 3/1) sand; many, coarse, distinct, dark grayish-brown (10YR 4/2) mottles; very weak, medium, subangular blocky structure; very friable; slightly acid; abrupt, smooth boundary.
C4—38 to 60 inches, brown (10YR 5/3) sand; single grain; loose; very dark brown (10YR 2/2) chunks intermixed with the matrix color; neutral.

The color of the A1 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The texture of this horizon is either sandy loam or sand that is high in organic-matter content.

The C horizon has a hue of 10YR, values of 3 to 6, and chromas of 1 to 4; the mottles in this horizon have values of 5 or less and chromas mainly of 1 or 2. The texture of the C horizon ranges from the predominant sand to loamy sand. Within the C horizon, in places, is a thin layer of organic matter or a thin layer of dark-colored alluvium. In places there are one or more layers of finer textured material, 1 to 3 inches thick. The thickness and sequence of the C horizons below a depth of 13 inches vary considerably.

The reaction ranges from medium acid to moderately alkaline. Normally, it is medium acid to slightly acid in the C1 and C2 horizons and neutral to moderately alkaline in the lower horizons.

The depth to mottling ranges from 10 to about 20 inches.

Algansee soils are similar to Glendora soils but occur at slightly higher elevations and consequently have better drainage and are flooded less often. Algansee soils are also similar to Au Gres soils, but they lack the A2 horizon and the Bhir horizon that are characteristic of Au Gres soils.

Algansee loamy sand (0 to 6 percent slopes) (Ak).—This soil is on flood plains, mainly in the western part of the county. Many areas are on natural levees; these areas are long and narrow and have gentle slopes. Broader areas occur on lower, nearly level parts of the flood plains.

In some areas this Algansee soil is better drained than is typical and has a thinner and lighter colored surface layer. Included in mapping were small areas of Glendora soils.

Fertility is low, runoff is slow, and permeability is rapid.

Most areas of this soil are in woods or pasture. (Capability unit IIIw–14 (L–4c) ; woodland suitability group O)

Allendale Series

The Allendale series consists of somewhat poorly drained soils on lake plains. These soils are underlain with silty clay at a depth of 18 to 40 inches.

In a typical profile, the surface layer consists of very dark brown sandy loam and is about 8 inches thick. Below it is a 4-inch subsurface layer of light brownish-gray loamy sand. The upper 14 inches of the subsoil consists of yellowish-brown, friable loamy sand over dark-brown, friable loamy sand. Below this is an 8-inch layer of pale-brown, mottled, friable loamy sand. At a depth of about 34 inches is a layer of yellowish-brown, mottled sandy clay, and below that, at a depth of about 39 inches, is the underlying material of grayish-brown, mottled, limy silty clay.

Fertility is medium. Permeability is rapid in the upper layers and slow in the clayey lower layers. If the fluctuating high water is corrected by artificial drainage, the available water capacity is moderate.

Many areas are cleared and cultivated. Artificial drainage is needed for most crops. Installing drainage systems is difficult because of the sandy texture of the subsoil and the clayey texture of the underlying material. In wooded areas, the vegetation consists mainly of lowland hardwoods, including red maple, elm, ash, and birch; it also includes some white pine.

Typical profile of Allendale sandy loam, cultivated, located in the SW¼SW¼NW¼ sec. 16, T. 7 N., R. 14 W. (Allendale Township) :

Ap—0 to 8 inches, very dark brown (10YR 2/2) sandy loam; weak, coarse, granular structure; friable; medium acid (pH 6.0) ; abrupt, smooth boundary.

A2—8 to 12 inches, light brownish-gray (10YR 6/2) loamy sand; few, medium, distinct, yellowish-brown (10YR 5/4) mottles; weak, coarse, subangular blocky structure; friable; medium acid (pH 6.0) ; clear, wavy boundary.

B21ir—12 to 18 inches, yellowish-brown (10YR 5/8) loamy sand; many, medium, prominent, light brownish-gray (2.5Y 6/2) mottles; weak, medium, subangular blocky structure; friable; slightly acid (pH 6.5) ; gradual, wavy boundary.

B22ir—18 to 26 inches, dark-brown (7.5YR 4/3) loamy sand; many, medium, distinct, yellowish-red (5YR 4/8) mottles; moderate, medium, subangular blocky structure; friable; slightly acid (pH 6.5) ; clear, wavy boundary.

A'2—26 to 34 inches, pale-brown (10YR 6/3) light loamy sand; many, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, coarse, subangular blocky structure; very friable; slightly acid (pH 6.5) ; clear, wavy boundary.

IIB't—34 to 39 inches, yellowish-brown (10YR 5/4) sandy clay; common, medium, prominent, grayish-brown (2.5Y 5/2) mottles; weak, medium, subangular blocky structure; friable to firm; cracks and voids filled with pale-brown (10YR 6/3) loamy sand; neutral (pH 7.0) ; gradual, wavy boundary.

IICg—39 to 60 inches, grayish-brown (10YR 5/2) silty clay; many, fine, distinct, light-gray (2.5Y 7/2) mottles; weak, medium, angular blocky structure; firm; calcareous.

The thickness of the solum above the IIB't horizon ranges from 18 to 40 inches. The reaction of this part is predominantly medium acid to slightly acid. For the entire solum, the range in reaction is from very strongly acid to neutral.

The color of the Ap horizon ranges to very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2). The texture of this horizon is sandy loam or loamy sand. The color of the A2 horizon ranges to light gray (10YR 6/1). In some cultivated areas the A2 horizon is lacking.

In places there is a Bhir horizon that is 2 to 6 inches thick and ranges from dark reddish brown (5YR 3/2) to dark brown (10YR 3/3) in color. The color of the B22ir horizon ranges to yellowish brown (10YR 5/8) or reddish brown (5YR 4/4). The texture of this horizon is sand or loamy sand. Weakly cemented chunks of ortstein occur in the B22ir horizon in places.

The color of the A'2 horizon ranges to pinkish gray (7.5YR 6/2). The texture of this horizon is sand or loamy sand. In places material of this description occurs as thick coatings on ped surfaces in the upper part of the IIB't horizon.

The matrix color of the IIB't horizon ranges to dark brown (7.5YR 4/4), and the texture of this horizon ranges to heavy sandy clay loam, silty clay loam, or silty clay.

The color of the IICg horizon ranges to brown (10YR 5/3 or 7.5YR 5/2–5/4).

Allendale soils are similar to Iosco soils but have a finer textured IICg horizon. Allendale soils occur with Au Gres soils, which lack the finer textured IIB't and IICg horizons that are typical of Allendale soils.

Allendale sandy loam, 0 to 4 percent slopes (AlA).—This soil occurs on lake plains. The largest areas are in Polkton, Allendale, Blendon, and Crockery Townships.

In some areas of this soil, thin layers of silty material occur within the clayey substratum. In other areas, the substratum consists of clay loam rather than silty clay. The crests of some slopes are eroded, and in such places the surface layer is lighter colored than is typical. Included in mapping were small areas of poorly drained Brevort and Pinconning soils, which are at the base of gentle slopes and in minor depressions. Also included were spots of Au Gres soils.

Fertility is medium. Permeability is rapid in the upper layers and slow in the underlying material. The water table is within a few feet of the surface in wet weather. Because of the fine texture of the underlying material and the variations in depth to it, installing an adequate drainage system is likely to be difficult. The soil is susceptible to both water erosion and soil blowing (fig. 6).

Most areas of this soil have been cleared and are cultivated. Some are idle at present, others are used for pasture, and a few are still in woods. (Capability unit IIIw–7 (4/1b) ; woodland suitability group G)

Au Gres Series

The Au Gres series consists of somewhat poorly drained soils that occur on outwash plains and lake plains.

In a typical profile, the surface layer consists of dark-gray loamy sand and is about 5 inches thick. Below this is a 3-inch subsurface layer of light-gray, mottled sand. The uppermost 5 inches of the subsoil is dark reddish-brown, very friable sand that contains a few small chunks of weakly cemented material. The next 17 inches is dark-

Figure 6.—**Windbreak grown to help control soil blowing in an area of Allendale sandy loam, 0 to 4 percent slopes.**

brown, mottled, loose sand, and below this is a 12-inch layer of brownish-yellow, mottled, loose sand. The underlying material, at a depth of about 42 inches, is light yellowish-brown, mottled sand.

Fertility is low, the available water capacity is low, and permeability is rapid. The water table is within a few feet of the surface in winter and spring. In summer the water table recedes, and the soils become droughty and susceptible to blowing.

Most areas of these soils have been cleared, but many are now idle or in second-growth forest. Blueberries, strawberries, pickling cucumbers, and other special crops are grown in a few areas. The native vegetation is a mixture of hardwoods and conifers, including red maple, aspen, birch, ash, elm, and white pine.

Typical profile of Au Gres loamy sand, disturbed, located in the NE¼SW¼SW¼NW¼ sec. 3, T. 6 N., R. 16 W. (Port Sheldon Township):

Ap—0 to 5 inches, dark-gray (10YR 4/1) loamy sand; weak, fine, granular structure; very friable; medium acid (pH 6.0); abrupt, smooth boundary.

A2—5 to 8 inches, light-gray (10YR 6/1) sand; common, fine, prominent, dark reddish-brown (5YR 3/3) mottles; weak, fine, granular structure; very friable; medium acid (pH 5.8); abrupt, irregular boundary.

B21hir—8 to 13 inches, dark reddish-brown (5YR 3/3) sand; weak, coarse, subangular blocky structure; very friable; a few chunks of weakly cemented ortstein or iron concretions, ¼ inch to 2 inches in diameter; strongly acid (pH 5.5); clear, irregular boundary.

B22ir—13 to 30 inches, dark-brown (7.5YR 4/4) sand; common, medium, prominent, brownish-yellow (10YR 6/6) mottles; single grain; loose; medium acid (pH 6.0); clear, irregular boundary.

B3—30 to 42 inches, brownish-yellow (10YR 6/6) sand; common, medium, faint, yellowish-brown (10YR 5/6) mottles; single grain; loose; slightly acid (pH 6.5); gradual, wavy boundary.

C—42 to 66 inches, light yellowish-brown (10YR 6/4) sand; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; slightly acid (pH 6.5).

The thickness of the solum ranges from 24 to about 42 inches. The reaction of the solum is dominantly strongly acid or medium acid but ranges from very strongly acid to slightly acid.

In undisturbed areas the profile includes an A1 horizon that is 2 to 5 inches thick, is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in color, and is of loamy sand or sand texture.

The color of the Ap horizon ranges to very dark gray (10YR 3/1), dark gray (10YR 4/1), or very dark grayish brown (10YR 3/2). The texture of this horizon is loamy sand or sand. In places the Ap horizon is nearly 10 inches thick and the A2 horizon is thin or nonexistent. The color of the A2 horizon ranges to light gray (10YR 7/1) or light brownish gray (10YR 6/2). Mottles in this horizon are few to common.

In the Bir horizons, the colors have a hue of 5YR or 7.5YR, a value of 3 or 4, and a chroma of 3, 4, or 6. The chunks of ortstein are most common where Au Gres soils grade to Saugatuck soils. In some places the B21hir horizon is very faintly mottled. The mottles in the B22ir horizon are faint to prominent.

The color of the C horizon ranges to pale brown (10YR 6/3) or very pale brown (10YR 7/3–7/4). In some places there is a thin, discontinuous color Bg horizon below a depth of 42 inches.

Au Gres soils formed in material similar to that in which Croswell and Saugatuck soils formed, but Au Gres soils are wetter and are mottled nearer the surface than Croswell soils, and they lack the continuous cemented Birm horizon that is characteristic of Saugatuck soils. Au Gres soils are in the same drainage class as Allendale and Iosco soils, but they lack the finer textured IICg horizon that occurs within 40 inches of the surface in Allendale and Iosco soils.

Au Gres loamy sand, 0 to 6 percent slopes (AmB).—This soil occurs on outwash plains and lake plains. It is predominantly nearly level. In some areas soil material blown from adjacent areas has accumulated in the form of hummocks 1 foot to 3 feet high and approximately 5 to 10 feet wide.

This soil has the profile described as typical of the series. In some areas the subsurface layer is thicker than is typical and is free of mottling. In other places the subsoil is lighter colored than the one in the typical profile. In areas that have been disturbed, the surface layer has been removed by soil blowing and the light-gray subsurface layer is exposed. Included in mapping were areas of the darker colored, more poorly drained Granby soils, which are at the base of gentle slopes, and small spots of Saugatuck soils, which have a continuous cemented pan.

This Au Gres soil is low in fertility. The water table is near the surface in winter and spring. When it recedes in summer, the soil becomes droughty and highly susceptible to blowing.

This soil is poorly suited to most crops. Many areas were cleared and cultivated in the past, but most of these are now idle or are either reforesting naturally with low-quality, second-growth hardwoods or are being planted with pine intended for Christmas trees. Blueberries, melons, strawberries, and pickling cucumbers can be grown in selected areas, but all these crops need special fertilization and supplemental irrigation. Some areas are still in native vegetation, which consists of quaking aspen, maple, birch, sweetgum, and white pine. (Capability unit IVw–2 (5b) ; woodland suitability group F)

Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes (ArB).—This soil is on outwash plains and lake plains.

The upper part of the profile of this soil is similar to the one described as typical for the series, but the substratum is clay loam or silty clay loam instead of sand. The depth to the substratum ranges from 42 to 66 inches. Where this soil grades to Allendale or Iosco soils, the substratum is at a depth of 42 to 48 inches. Included in mapping were eroded areas in which either the subsurface layer or the subsoil is exposed. Also included were areas of the darker colored, more poorly drained Granby and Brevort soils in minor depressions and drainageways. Other inclusions are spots of Iosco and Allendale soils. In Brevort, Allendale, and Iosco soils, a finer textured substratum is within 40 inches of the surface.

This Au Gres soil is low in fertility. The water table is near the surface in wet weather, and lowering it by artificial drainage is difficult. In summer, when the water table recedes, the soil becomes droughty and susceptible to blowing.

Many areas of this soil were cleared and cultivated in the past but are now idle or used for pasture. Other areas are reforesting naturally with a mixture of low-quality lowland hardwoods or are being planted with pines. There are a few woodlots of second-growth native trees. Corn, small grain, and hay are grown in some places. (Capability unit IVw–2 (5b) ; woodland suitability group F)

Au Gres-Saugatuck sands, 0 to 6 percent slopes (AsB).—This complex occurs mainly on sandy plains in the western part of the county. The two kinds of soils are associated in such intricate patterns that neither can be shown separately on the soil map.

Most areas of this complex are 60 percent Au Gres sand, 25 percent Saugatuck sand, and 15 percent other soils. The Au Gres soil is gently sloping; at the crests of slopes are areas of moderately well drained Croswell soils. The Saugatuck soil is in shallow, dish-shaped depressions, along with inclusions of poorly drained Granby soils. A cemented subsoil is characteristic of the Saugatuck soil.

Fertility is low. The water table is near the surface part of the year. When the water table recedes during the dry months of summer, the soils become very droughty. Plant roots do not penetrate the cemented layer in the Saugatuck soil. Soil blowing is a hazard when the soils are dry and bare.

These soils are poorly suited to most crops. Most areas that have been cleared and cultivated in the past are now covered with grasses and weeds and scattered clumps of aspen, sassafras, and sumac. Some areas have been planted with Scotch pine, red pine, white pine, jack pine, or spruce. Some have reforested naturally with jack pine, aspen, elm, and white pine; these naturally wooded areas have a dense ground cover of greenbrier. Blueberries, which need an acid, wet soil, are grown in some areas (fig. 7), and melons, strawberries, and cucumbers are grown on small acreages. All these crops need special fertilization and supplemental irrigation. (Capability unit IVw–3 (Au Gres—5b, Saugatuck—5b–h) : woodland suitability group F)

Belding Series

This series consists of somewhat poorly drained soils that occur mainly in upland depressions, on benches, and along the margins of till plains and lake plains. These soils are underlain with clay loam or silty clay loam at a depth of 18 to 40 inches.

In a typical profile, the surface layer consists of very dark gray sandy loam and is about 8 inches thick. Below it is a 3-inch subsurface layer of grayish-brown sandy loam mottled with dark gray. The subsoil is about 17 inches thick. The uppermost 4 inches is dark-brown and dark reddish-brown, very friable loamy sand; the next 4 inches is strong-brown, mottled, friable sandy loam; below this is a 5-inch layer of yellowish-brown, very friable loamy sand; and the lowest layer is yellowish-brown, mottled, firm sandy clay loam, about 4 inches thick. The underlying material, which extends from a depth of 28 inches to a depth of 66 inches, is gray, calcareous clay loam.

Fertility is medium, and the available water capacity is moderate. Permeability is moderately rapid in the upper 18 to 40 inches and moderately slow at greater depths. In spring, the water table is near the surface.

Belding soils are well suited to crops if properly managed. Most of the acreage is cultivated. Some areas are idle, and some are covered with second-growth trees. The native vegetation was a mixture of hardwoods and conifers, including maple, ash, birch, white pine, and hemlock.

Typical profile of a Belding sandy loam, cultivated, located in the SE¼SW¼SW¼ sec. 1, T. 5 N., R. 15 W. (Holland Township) :

Ap—0 to 8 inches, very dark gray (10YR 3/1) sandy loam; moderate, medium, subangular blocky structure; friable; medium acid; abrupt, smooth boundary.

A2–8 to 11 inches, grayish-brown (10 YR 5/2) sandy loam; common, coarse, distinct, dark-gray (10YR 4/1) mot-

Figure 7.—**Blueberry plantation in an area of Au Gres-Saugatuck sands, 0 to 6 percent slopes. Cover crop of oats between rows of bushes helps to control soil blowing.**

tles; weak, coarse, subangular blocky structure; friable; medium acid; clear, broken boundary.

B21hir—11 to 15 inches, dark-brown (7.5YR 3/2) and dark reddish-brown (5YR 3/4) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, irregular boundary.

B22ir—15 to 19 inches, strong-brown (7.5YR 5/6) sandy loam; common, medium, prominent, gray (10YR 6/1) mottles; moderate, medium, subangular blocky structure; friable; gray (10YR 6/1) sand coatings on ped surfaces and in voids; strongly acid; clear, wavy boundary.

B3—19 to 24 inches, yellowish-brown (10YR 5/6) loamy sand; many, medium, faint, light yellowish-brown (10YR 6/4) mottles; very friable; medium acid; clear, broken boundary.

IIB'2t—24 to 28 inches, yellowish-brown (10YR 5/6) sandy clay loam; common, medium, distinct, gray (10YR 6/1) mottles; weak, coarse, subangular blocky structure grading to massive; firm; slightly acid; clear, wavy boundary.

IICg—28 to 66 inches, gray (10YR 6/1) clay loam; many, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, angular blocky structure; firm; calcareous.

The combined thickness of the sandy loam and loamy sand layers ranges from 18 to 40 inches.

In undisturbed areas there is an A1 horizon that is 2 to 5 inches thick, is very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2) in color, and in texture ranges from loamy sand to fine sandy loam but is predominantly sandy loam. The color of the Ap horizon ranges from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2). The A2 horizon ranges in color to pinkish gray (10YR 6/2); its texture is loamy sand or sandy loam; and in places it has a weak, platy structure.

The color of the B21hir horizon ranges to dark brown (7.5YR 4/4), dark reddish brown (5YR 3/3), and dark yellowish brown (10YR 4/4). In some places this horizon is mottled. The texture of the B21hir, the B22ir, and the B3 horizons is either loamy sand or sandy loam. Each of these horizons contains a considerable amount of gravel in places, and the soil material is gritty.

In some places there is an A'2 horizon just above the IIB'2t horizon. The A'2 horizon is as much as 8 inches thick. Its color ranges from light grayish brown (10YR 6/2) to pale brown (10YR 6/3) to grayish brown (10YR 5/2); its texture is light loamy sand or sandy loam; its structure is weak, medium or fine, subangular blocky or platy. During periods of dry weather, this horizon becomes hard and brittle and has the appearance of a fragipan. In some places material of this description occurs only as ped coatings and crack fillings in the upper part of the IIB'2t.

The matrix color of the IIB'2t horizon ranges to dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4 or 7.5YR 5/6), brown (10YR 5/3), and pale brown (10YR 6/3). The texture ranges to silty clay or heavy loam.

The texture of the IICg horizon ranges to light clay loam or silty clay loam. This layer is neutral in reaction and in places is calcareous.

The reaction of the solum ranges from slightly acid to strongly acid.

Belding soils are more poorly drained and more mottled than Ubly soils, which formed in similar materials. Belding soils are similar to Allendale and Kawkawlin soils in drainage. They have a finer textured B22ir horizon and a coarser textured IICg horizon than Allendale soils, and they have a coarser textured B horizon than Kawkawlin soils.

Belding sandy loam, 0 to 2 percent slopes (BeA).—This soil occurs along the margin of lake plains and till plains, where the plains join the uplands, and in depressions and draws in the uplands. Nearly all of it is in the eastern part of the county.

This soil has the profile described as typical of the series. In places, mostly in Wright Township, the sandy loam layers extend to a depth of more than 40 inches. In other places there is a gravelly layer just above the fine-textured underlying material. Some of the areas mapped include

spots of Iosco soils; of Breckenridge soils, which are poorly drained; and of soils in which clay loam occurs at a depth of less than 18 inches. Also included are small stony areas (shown on the soil map by stone symbols) and a few areas in which the slope is slightly more than 2 percent.

Fertility is medium, the available water capacity is moderate, and runoff is slow. Permeability is moderately rapid in the uppermost 18 to 40 inches and moderately slow at greater depths. The water table is near the surface in spring but recedes in summer. Moderately slow permeability in the underlying material keeps the upper layers wet after long periods of wet weather.

If artificially drained and otherwise well managed, this soil is well suited to most crops. Most areas have been cleared and are cultivated. Cropping systems commonly include corn, small grain, and hay. Some areas are now idle, some are in permanent pasture, and some are still wooded. (Capability unit IIw–8 (3/2b); woodland suitability group G)

Belding sandy loam, 2 to 6 percent slopes (BeB).—This soil occurs along the margin of lake plains and till plains, where the plains join the uplands. It also occurs on toe slopes, in draws, and on benches in the uplands. Slopes are mainly long and gentle, but shorter, steeper slopes occur in some areas. Nearly all areas of this soil are in the eastern part of the county.

In some areas of this soil, the surface layer has been mixed with the subsurface layer by cultivation, erosion, and blowing, and the result is a surface layer that is lighter colored than is typical. In places the subsurface layer is lacking, and in small areas, mainly on low knolls and on the crest of slopes, the dark-brown subsoil is at the surface. There are areas, mostly in Wright Township, where the sandy loam layers extend to a depth of more than 40 inches, and other areas in which the subsoil contains a considerable amount of gravel. Included in mapping were spots of Iosco soils, which are more sandy than Belding soils; spots of Breckenridge soils, which are poorly drained; and spots of soils in which clay loam occurs at a depth of less than 18 inches. Also included are some areas, generally small, in which the slope is less than 2 percent.

Fertility is medium, the available water capacity is moderate, and runoff is medium. Permeability is moderately rapid in the uppermost 18 to 40 inches and moderately slow at greater depths. The water table is near the surface in spring but recedes in summer. Moderately slow permeability in the underlying material keeps the upper layers wet after long periods of wet weather and also causes seep spots. The erosion hazard is moderate.

If artificially drained and otherwise well managed, this soil is well suited to most crops. Nearly all areas have been cleared and cultivated. Cropping systems commonly include corn, small grain, and hay. Some areas are idle, some are in permanent pasture, and a few are wooded. (Capability unit IIw–8 (3/2b); woodland suitability group G)

Blount Series

The Blount series consists of somewhat poorly drained soils that occur on glacial till plains in the southeastern part of the county.

In a typical profile, the surface layer consists of dark-brown loam and is about 8 inches thick. Below this is a 4-inch subsurface layer of pale-brown loam. The subsoil is about 13 inches thick; the upper 4 inches is strong-brown, mottled, firm clay loam, and the lower 9 inches is grayish-brown, mottled, firm heavy clay loam. The underlying material, at a depth of 25 inches, is brown, mottled, limy clay loam.

Fertility is high, the available water capacity is high, and permeability is moderately slow.

Blount soils are good for farming. Most areas have been cleared and are cultivated. Artificial drainage is needed for most crops. A few areas are still wooded. The native vegetation consists of maple, oak, hickory, and beech.

Typical profile of Blount loam, 0 to 2 percent slopes, cultivated, located in the NE¼SE¼NE¼ sec. 3, T. 5 N., R. 13 W. (Jamestown Township):

Ap—0 to 8 inches, dark-brown (10YR 4/3) loam; moderate, medium, granular structure; friable; medium acid; abrupt, smooth boundary.

A2—8 to 12 inches, pale-brown (10YR 6/3) loam; few, fine, faint, brownish-yellow (10YR 6/8) mottles; moderate, medium, platy structure; friable; strongly acid; clear, wavy boundary.

B21t—12 to 16 inches, strong-brown (7.5YR 5/6) clay loam; common, fine, prominent, light-gray (10YR 7/2) mottles; few, fine, prominent, pale-brown (10YR 6/3) mottles; moderate, medium, subangular blocky structure; firm; very strongly acid; clear, wavy boundary.

B22tg—16 to 25 inches, grayish-brown (10YR 5/2) heavy clay loam; many, medium, distinct, brownish-yellow (10YR 6/8) mottles and dark-brown (10YR 4/3) clay films on ped faces in lower part; strong, coarse, subangular blocky structure; firm; slightly acid; gradual, wavy boundary.

C—25 to 50 inches, brown (10YR 5/3) clay loam; many, coarse, distinct, yellowish-brown (10YR 5/8) mottles; many, fine, prominent, light-gray (N 7/0) vertical lime streaks in uppermost 5 inches; weak, coarse, angular blocky structure; firm; calcareous.

The solum is 20 to 36 inches thick and is very strongly acid to slightly acid.

In undisturbed areas the profile includes a 3- to 5-inch A1 horizon of very dark grayish-brown (10YR 3/2) or dark-brown (10YR 3/3 loam or silt loam.

The texture of the Ap horizon is silt loam in some places. The A2 horizon has a subangular blocky rather than a platy structure in places. It ranges in color to grayish brown (10YR 5/2) or brown (10YR 5/3) and is faintly to prominently mottled.

The texture of the B21t horizon ranges from light clay loam to heavy clay loam. The color of this horizon ranges to dark brown (7.5YR 4/4), strong brown (7.5YR 5/8), or dark yellowish brown (10YR 4/4). The mottles have a value of 5, 6, or 7 and generally a chroma of 2 or less. In the B22tg horizon, the color ranges to brown (10YR 5/3) or yellowish brown (10YR 5/4), and the mottles have a value of 4, 5, or 6 and a chroma of 1 through 8. Where the matrix color has a chroma of more than 2, low-chroma coatings occur on the faces of peds. In some places the profile includes a B3 horizon characterized by thin, patchy clay films and a neutral or mildly alkaline reaction.

The C horizon is clay loam or silty clay loam in texture, and it ranges in color to grayish brown (10YR 5/2) or yellowish brown (10YR 5/4).

Blount soils occur near Morley, Metamora, and Sims soils. They are less well drained than Morley soils and are mottled nearer the surface; they are finer textured in the upper part of the B horizon than Metamora soils; and they are better drained than Sims soils and are free of mottles to a greater depth. Blount soils are in the same drainage class as Bowers soils, but they lack the stratification that is characteristic of Bowers soils.

Blount loam, 0 to 2 percent slopes (BlA).—This soil is on glacial till plains in the southeastern part of the county. Most of the areas are in Jamestown, Georgetown, and Zeeland Townships.

This soil has the profile described as typical of the series. Included in mapping were small areas of the darker colored, more poorly drained Sims soils, which are in draws and depressions, and a few spots of Metamora soils, which are coarser textured than Blount soils.

Fertility is high, the available water capacity is high, and permeability is moderately slow.

This soil can be cropped intensively if artificially drained. (Capability unit IIw–2 (1.5b); woodland suitability group Z)

Blount loam, 2 to 6 percent slopes (BlB).—This soil is on glacial till plains in the southeastern part of the county. Most of the areas are in Jamestown, Georgetown, and Zeeland Townships.

Included in mapping were eroded areas where part of the original surface layer has been removed and the rest has been mixed with strong-brown clay loam from the subsoil. Other inclusions are small areas, mainly on and near the crests of slopes, where the soil is better drained and lighter colored than is typical. Small areas of the darker colored, more poorly drained Sims soils, in drainageways and depressions, are also included.

This soil is suitable for crops, but it needs artificial drainage and protection against erosion. Because of the gentle slopes, water does not ordinarily stand on the surface except in the included drainageways and depressions. (Capability unit IIw–3 (1.5b); woodland suitability group Z)

Blown-Out Land

Blown-out land consists of areas of sandy soils that were cleared of their original forest cover and left exposed to the erosive action of water and wind. Some areas have been stabilized, but others are actively eroding.

Blown-out land, 0 to 6 percent slopes (BoB).—This unit occurs throughout the open sandy areas of the county and on severely eroded sand dunes near Lake Michigan. The original surface layer and subsoil have been removed, and loose sand is at the surface. Active blow-outs make up between 20 and 50 percent of any given area, and soil material is accumulating in some areas between blow-outs. Included in mapping were some less severely eroded areas.

This land type is not suitable for crops, but trees can be grown on it. All of the acreage needs to be protected against further erosion. Some areas have been stabilized with planted beachgrass, and some areas thus stabilized have been reforested with red pine, Scotch pine, pitch pine, or jack pine. The present natural vegetation consists of moss and lichen and scattered scrub oak and fire cherry. In some areas the surface is covered only with lag gravel, and in some the loose sand is exposed. (Capability unit VIIs–1 (5.3a); woodland suitability group Y)

Blown-out land, 6 to 50 percent slopes (BoF).—This unit occurs throughout the open sandy areas of the county and on active sand dunes along Lake Michigan. Some of the original subsoil remains on lee slopes and in other sheltered spots, but in most areas the original surface layer and subsoil have been removed and loose sand that was originally the substratum is at the surface. Active blow-outs make up between 20 and 50 percent of any given area, and accumulations of soil material occur at the base of and on the leeward side of slopes. In several places the dunes are expanding eastward and covering other soils.

This land type is not suited to crops, but trees can be grown on it. All of the acreage needs to be protected against further erosion. Some areas have been stabilized with planted beachgrass or with a brush mulch, and some areas thus stabilized have been reforested with pitch pine, red pine, jack pine, or locust. The present natural vegetation consists of a sparse cover of moss and lichen. In some areas the surface is covered only with a thin mantle of lag gravel, and in some the loose sand is exposed. The dunes along the lake are used mainly for recreation and as wildlife habitat. (Capability unit VIIs–1 (5.3a); woodland suitability group Y)

Bowers Series

The Bowers series consists of somewhat poorly drained soils that occur on lake plains and on water-worked till plains.

In a typical profile, the surface layer consists of dark grayish-brown loam and is about 7 inches thick. Below this is a 4-inch subsurface layer of light brownish-gray, mottled fine sandy loam. The subsoil is about 18 inches thick. The upper 9 inches consists of yellowish-brown, mottled, firm clay loam and light brownish-gray, firm sandy loam. The lower 9 inches is yellowish-brown, mottled, very firm heavy silty clay loam. The underlying material, at a depth of about 29 inches, is brown, mottled, limy silty clay loam stratified with thin layers of silt loam.

Fertility is high, the available water capacity is high, and permeability is moderately slow.

Bowers soils are good for farming. Most areas have been cleared and cultivated. Artificial drainage is needed for most crops. Some areas formerly cultivated are now idle or are used for hay and pasture. A few areas are still wooded. The native vegetation consists mainly of hardwoods, including maple, ash, elm, birch, and beech. In addition, the stands contain hemlock.

Typical profile of Bowers loam, 2 to 6 percent slopes, cultivated, located in the SE¼SE¼SE¼ sec. 12, T. 6 N., R. 15 W. (Crockery Township):

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

A2—7 to 11 inches, light brownish-gray (10YR 6/2) fine sandy loam; few, fine, distinct, very dark grayish-brown (10YR 3/2) mottles; weak, medium, subangular blocky structure; friable; slightly acid; abrupt, irregular boundary.

B&A—11 to 20 inches, yellowish-brown (10YR 5/4) clay loam with many, fine, prominent, yellowish-red (5YR 5/8) mottles, representing the B horizon, and light brownish-gray (10YR 6/2) sandy loam, representing the A horizon; moderate, medium, subangular blocky structure; firm; peds coated with, and cracks and voids filled with, light brownish-gray (10YR 6/2) sandy loam, becoming less apparent with depth; slightly acid; clear, irregular boundary.

B22t—20 to 29 inches, yellowish-brown (10YR 5/4) heavy silty clay loam; many, fine, distinct, gray (10YR 5/1) mottles and few, fine, distinct, yellowish-brown (10YR 5/8) mottles; strong, medium, angular blocky structure; very firm; neutral; clear, wavy boundary.

C—29 to 50 inches, brown (10YR 5/3) silty clay loam stratified with a few ⅛-inch to 2-inch layers of silt loam; many, fine, prominent, pinkish-gray (5YR 7/2) mottles and

few, fine, prominent, red (2.5YR 5/6) mottles; moderate, medium, angular blocky structure; firm; calcareous.

The solum is 20 to 36 inches thick. In reaction it ranges from medium acid to neutral.

In undisturbed areas the profile includes a 3- to 5-inch A1 horizon of very dark gray (10YR 3/1) loam or silt loam

In places the Ap horizon is silt loam instead of loam. The A2 horizon is sandy loam, fine sandy loam, loam, or silt loam. In color it ranges to gray (10YR 5/1) or grayish brown (10YR 5/2). The mottles have a chroma of 2 or less. In some places the profile lacks an A2 horizon.

The texture of the B22t horizon is heavy silty clay loam, silty clay loam, or heavy clay loam. The color ranges to grayish brown (10YR 5/2) or brown (10YR 5/3). The mottles have a chroma of 2 or less.

The C horizon contains thin strata of silt loam, loam, or fine sandy loam.

Bowers soils occur near Nester, Hettinger, and Kawkawlin soils. They are more mottled than Nester soils, they are less gray than the poorly drained Hettinger soils, and they differ from Kawkawlin soils in having thin layers of coarser textured material in the lower part of the subsoil and in the substratum.

Bowers loam, 0 to 2 percent slopes (BpA).—This soil occurs on lake plains and on water-worked till plains. It is scattered throughout the county but is most common in Crockery, Tallmadge, and Wright Townships.

In Tallmadge Township are a few areas in which the surface layer is darker colored than that in the typical profile and the profile includes layers of coarser textured material; in some of these areas, gravelly material occurs below a depth of 42 inches. Included in mapping were areas of better drained soils, on slight swells in the landscape, and areas of poorly drained Hettinger soils, in minor dips. Also included were eroded areas, in which the surface layer is lighter colored and the light brownish-gray subsurface layer commonly is lacking, and a few spots, mostly in Crockery Township, in which the profile is finer textured throughout.

This soil is suitable for farming but needs artificial drainage for most crops. Most areas have been cleared and are cultivated, but a few areas are still in woods. (Capability unit IIw–2 (1.5b); woodland suitability group Z)

Bowers loam, 2 to 6 percent slopes (BpB).—This soil occurs on lake plains and water-worked till plains. Many areas are in Crockery, Tallmadge, and Wright Townships.

This soil has the profile described as typical of the series. There are places in Talmadge Township, mostly in the west-central part, where the surface layer is darker colored than that in the typical profile and the layers below a depth of 42 inches are coarser textured and in spots gravelly. In and around Eastmanville are areas in which the texture is finer than is typical and the thin layers of coarser textured material are lacking. The slopes are predominantly long and of less than 5 percent gradient. In small areas where the gradient exceeds 5 percent, the surface layer is lighter colored and in places is eroded. Included in mapping were areas of Hettinger soils, which are in minor dips, depressions, and drainageways.

This soil is suitable for farming, but it needs artificial drainage and protection against erosion. Nearly all areas have been cleared and are cultivated. Some areas are used for hay and pasture, and a few are wooded. Because of the gentle slopes, water does not ordinarily stand on the surface except in the included drainageways and depressions. (Capability unit IIw–3 (1.5b); woodland suitability group Z)

Boyer Series

The Boyer series consists of well-drained soils that occur on broad outwash plains and sandy moraines located mainly in the southeastern part of the county. These soils are underlain with sand and gravel at a depth of 24 to 42 inches.

In a typical profile, the surface layer consists of dark-brown loamy sand and is about 6 inches thick. Below this is a 24-inch subsurface layer of brown sand. The subsoil, about 6 inches thick, consists of reddish-yellow, friable gravelly sandy loam. The underlying material, at a depth of about 36 inches, is light brownish-gray, limy gravel and coarse sand.

Fertility is low, the available water capacity is low, and permeability is rapid. The soils warm up early in spring and become droughty in summer.

Most areas of Boyer soils have been cleared and cultivated, but many are now idle or are used for hay and pasture (fig. 8). Some areas are possible sites for housing developments. The substratum is a potential source of sand and gravel. There are a few second-growth woodlots. The native vegetation consists of hardwoods and some white pine. Among the hardwoods are sugar maple, oak, hickory, and aspen.

Typical profile of Boyer loamy sand, 0 to 2 percent slopes, cultivated, located in the S½SW¼NW¼NE¼ sec. 14, T. 6 N., R. 13 W. (Georgetown Township):

Ap—0 to 6 inches, dark-brown (10YR 4/3) loamy sand; weak, fine, granular structure; very friable; strongly acid; abrupt, smooth boundary.

A2—6 to 30 inches, brown (10YR 5/3) sand; single grain; loose; medium acid; clear, wavy boundary.

B2t—30 to 36 inches, reddish-yellow (7.5YR 6/8) gravelly sandy loam; weak, coarse, subangular blocky structure; friable; medium acid; clear, wavy boundary.

C—36 to 66 inches, light brownish-gray (10YR 6/2) sand and gravel; single grain; loose; calcareous.

The solum is 24 to 40 inches thick. In reaction it ranges from strongly acid to neutral. Gravel occurs in various amounts throughout the profile.

In undisturbed areas the profile includes a 1- to 5-inch A1 horizon of dark gray (10YR 4/1) or very dark gray (10YR 3/1) loamy sand or sand.

The texture of the Ap horizon is loamy sand or sandy loam, and the color ranges to very dark brown (10YR 2/2). In the A2 horizon, the texture is ordinarily sand or loamy sand but ranges from sand to sandy loam, and the color ranges to pale brown (10YR 6/3) or grayish brown (10YR 5/2).

In some areas the profile includes a 4- to 12-inch B1 horizon of yellowish-brown (10YR 5/4–5/6) loamy sand or light sandy loam.

In the B2 horizon the color has a hue of 5YR to 10YR, a value of 4, 5, or 6, and a chroma of 3 through 8. The soil material feels gritty. In places the lower boundary is very irregular and tongues of B2 material extend several inches into the calcareous C horizon.

Boyer soils are similar to Spinks and Oshtemo soils. They differ from Spinks soils in having a sandy and gravelly substratum. They have a thinner solum than Oshtemo soils; in Boyer soils the substratum is within 40 inches of the surface, and in Oshtemo soils it is at a much greater depth.

Boyer loamy sand, 0 to 2 percent slopes (BrA).—This soil occurs mainly on outwash plains in the southeastern part of the county.

This soil has the profile described as typical of the series. In some places the color of the surface layer is very dark brown, and in some the texture of this layer is sandy loam. Included in mapping were areas of Rubicon and Spinks soils, which lack the gravel and sand substratum that is

Figure 8.—**Beef cattle grazing on alfalfa in an area of a Boyer loamy sand.**

typical of Boyer soils. Also included were small areas of eroded soils that have a lighter colored surface layer, and small areas in which the slope is between 2 and 6 percent.

Fertility is low, and the available water capacity is low. Soil blowing is a hazard if crops are grown.

Most areas of this soil have been cleared and cultivated in the past, but some are now idle or in grass. Cropping systems commonly include more than 2 years of meadow. Limitations for urban uses are few, and areas next to existing urban communities are being put to such uses. Sand and gravel are being obtained from some areas. (Capability unit IIIs–3 (4a) ; woodland suitability group M)

Boyer loamy sand, 2 to 6 percent slopes (BrB).—This soil occurs on outwash plains in the southeastern part of the county and, to a limited extent, in areas of rolling topography. The slopes generally are less than 200 feet long, and many are much less than that.

In some places the color of the surface layer is very dark brown, and in some the texture is sandy loam. Included in mapping were areas of Rubicon and Spinks soils, which lack the underlying gravel and sand that is typical of Boyer soils. Also included were small areas of eroded soils in which the surface layer is dark grayish brown to dark yellowish brown and the underlying material is within 3 feet of the surface.

Most areas of this soil have been cleared and cultivated in the past, but many are now idle or in grass. Cropping systems commonly include more than 2 years of meadow. Limitations for urban uses are few, and areas near existing urban communities are being put to such uses. Sand and gravel are being obtained from some areas. (Capability unit IIIs–4 (4a) ; woodland suitability group M)

Boyer loamy sand, 6 to 12 percent slopes (BrC).—This soil occurs on the sides and tops of sandy hills in the southeastern part of the county and also on long, narrow breaks on outwash plains. The slopes generally are less than 200 feet long. The slopes are more uniform on the narrow breaks than on the sandy hills.

The texture of the surface layer is loamy sand or sandy loam. In most areas the brown subsurface layer is lacking and the subsoil is thinner than is typical, and in some places the subsoil is mixed with the surface layer. The depth to the underlying material ranges from 24 to 30 inches. Included in mapping were hummocks and eroded spots where the soil is lighter colored and in places very gravelly. Also included are slopes of more than 12 percent and of less than 6 percent.

Fertility is low, and the available water capacity is low. The soil erodes and blows readily.

Many areas have been cleared and are used for the common crops, mainly corn, small grain, and hay. Cropping systems commonly consist largely of close-growing crops. Second-growth woodlots occupy some areas. (Capability unit IIIe–9 (4a) ; woodland suitability group M)

Breckenridge Series

The Breckenridge series consists of poorly drained soils that occur on lake plains, till plains, and outwash plains.

These soils are underlain at a depth of about 35 inches with silty clay loam and clay loam.

In a typical profile, the surface layer consists of very dark gray sandy loam and is about 7 inches thick. Below this is a 7-inch layer of dark-gray and gray, mottled, friable sandy loam. At a depth of 14 inches is a layer of light-gray, mottled, very friable loamy sand, and below that, at a depth of 24 inches, a layer of yellowish-brown, mottled, friable sandy loam. The underlying material, at a depth of about 35 inches, consists of a 3-inch layer of light olive-brown, mottled, firm silty clay loam over a 12-inch layer of brown, mottled, limy clay loam.

Fertility is medium, and the available water capacity is moderate. Permeability is moderate in the upper part of the profile and moderately slow in the limy layer. Runoff is very slow and occasionally ponded. The water table is high. Frost is a hazard to crops.

Many areas of Breckenridge soils have been cleared and drained and are cultivated. Corn, small grain, and hay are the common crops. Areas cleared but not drained are used mainly for pasture, and some areas, mostly undrained, are idle. Still others have been left in woods. The native vegetation is a mixture of lowland hardwoods, including elm, ash, red maple, and a little sycamore.

Typical profile of Breckenridge sandy loam, cultivated, located in the SE¼SE¼SW¼ sec. 32, T. 6 N., R. 14 W. (Blendon Township):

Ap—0 to 7 inches, very dark gray (10YR 3/1) sandy loam; weak, medium, granular structure; friable; medium acid; abrupt, smooth boundary.

B2g—7 to 14 inches, dark-gray (10YR 4/1) and gray (10YR 6/1) sandy loam; common, medium, distinct, yellowish-brown (10YR 5/4) mottles; weak, coarse, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

A'2g—14 to 24 inches, light-gray (10YR 7/2) loamy sand; few, medium, distinct, very dark grayish-brown (10YR 3/2) mottles; weak, coarse, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B'2—24 to 35 inches, yellowish-brown (10YR 5/6) sandy loam; many, medium, distinct, grayish-brown (10YR 5/2) mottles; weak, coarse, subangular blocky structure; friable; neutral; clear, wavy boundary.

IIC1—35 to 38 inches, light olive-brown (2.5Y 5/6) silty clay loam; common, medium, prominent, gray (N 6/0) mottles; moderate, medium, subangular blocky structure; firm; mildly alkaline; gradual, wavy boundary.

IIC2g—38 to 50 inches, brown (7.5YR 5/2) clay loam; common, medium, prominent, gray (N 6/0) mottles; massive, parting to weak, coarse, subangular blocky structure; firm; moderately alkaline; calcareous.

The thickness of the solum ranges from 18 to 40 inches but is most commonly between 24 and 36 inches. The reaction of the solum ranges from strongly acid to neutral, and that of the C horizon from neutral to moderately alkaline.

In undisturbed areas the profile includes an A1 horizon of very dark gray (10YR 3/1) or black (10YR 2/1) sandy loam, and in some profiles there is a 3- to 10-inch layer of muck or peat.

The texture of the B2 horizon is predominantly sandy loam but ranges to loamy fine sand. The matrix color of this horizon ranges to dark grayish brown (10YR 4/2), and the mottles are faint to prominent. In places this horizon contains a few small chunks of very weakly cemented material.

In some profiles the A'2g horizon contains a considerable amount of gravel.

In some profiles the A'2g horizon contains considerable gray (10YR 6/1), light gray (10YR 7/2), or grayish brown (10YR 5/2). Instead of a B'2 horizon, some profiles have a IIB's horizon that is as much as 8 inches thick and has a sandy clay loam or clay loam texture. A few profiles have both a B'2 and a IIB'g horizon.

The IIC horizon is glacial till of clay loam or silty clay loam texture.

Breckenridge soils are similar to and occur near Belding, Brevort, Pinconning, and Sims soils. They have a finer textured B horizon than Brevort soils. They contain less coarse-textured material in the uppermost 18 to 40 inches and have a coarser textured IIC horizon than Pinconning soils. Breckenridge soils formed in the same kind of material as Belding soils, but they are more poorly drained and grayer than Belding soils. They have a coarser textured B horizon than Sims soils.

Breckenridge sandy loam (0 to 2 percent slopes) (Bu).—This nearly level to depressional soil occurs on outwash plains, till plains, and lake plains. It is most common near the edges of the till plains.

In some places the texture of the surface layer is loam, and in some it is loamy fine sand. Included in mapping were spots of Sims soils, which do not have sandy loam layers within the uppermost 18 to 40 inches, and of Brevort soils, in which sandy layers are just above the clay loam substratum. Also included were short slopes of more than 2 percent. In the southern half of the county are some included areas in which small deposits of gravel occur in the subsoil.

Fertility is medium, and the available water capacity is moderate. Permeability is moderate in the upper layers and moderately slow in the limy part of the substratum. Runoff is slow, and the water table is high. Frost is a hazard to crops. Artificial drainage is needed for most crops.

Many areas of this soil have been cleared, drained, and farmed. Cropping systems commonly include corn, small grain, and hay. Some areas are used only for pasture, and some are idle. A few are still wooded. (Capability unit IIw–8 (3/2c); woodland suitability group W)

Brevort Series

The Brevort series consists of poorly drained soils that occur on outwash plains, lake plains, and till plains. These soils are underlain at a depth of 18 to 40 inches with limy glacial till of clay loam or silty clay loam texture.

In a typical profile, the surface layer consists of very dark brown light sandy loam and is about 8 inches thick. Below this is a 17-inch subsurface layer of grayish-brown loamy sand. The subsoil, about 7 inches thick, consists of dark-gray, mottled, very friable loamy sand. The underlying material, at a depth of about 32 inches, is brown and gray, limy clay loam.

Fertility is low, and the available water capacity is moderate. Permeability is rapid in the uppermost 18 to 40 inches and moderately slow in the underlying material. Runoff is slow to ponded, and the water table is high. Frost is a hazard to crops.

Some areas of Brevort soils have been cleared, drained, and cultivated. Some are now idle. Areas cleared but not drained are used mainly for pasture. Many areas are still wooded. The native vegetation is mainly a mixture of lowland hardwoods but includes some conifers. Elm, ash, red maple, and birch are among the hardwoods; hemlock, arborvitae, and white pine are the conifers.

Typical profile of Brevort sandy loam, cultivated, located in the NE¼NE¼NW¼ sec 12, T. 5 N., R. 15 W. (Holland Township):

Ap—0 to 8 inches, very dark brown (10YR 2/2) light sandy loam; moderate, medium, granular structure; friable; neutral; abrupt, smooth boundary.

A2g—8 to 25 inches, grayish-brown (10YR 5/2) loamy sand; common, coarse, faint, dark-gray (10YR 4/1) mottles; weak, coarse, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

Bg—25 to 32 inches, dark-gray (10YR 4/1) loamy sand; few, medium, faint, grayish-brown (10YR 5/2) mottles; weak, coarse, subangular blocky structure; very friable; neutral; clear, wavy boundary.

IIC—32 to 50 inches, brown (10YR 5/3) and gray (10YR 6/1) clay loam; massive; firm, moderately alkaline; calcareous.

The solum is 18 to 40 inches thick. In reaction it ranges from medium acid to mildly alkaline. In some profiles the solum contains gravelly material.

The texture of the Ap horizon ranges from sand to light sandy loam, and the color ranges to black (10YR 2/1).

In some profiles the A2g and Bg horizons are replaced by a C1g horizon of gray (10YR 5/1) or light-gray (10YR 6/1) sand or loamy sand. This C1g horizon ranges up to 32 inches in thickness. The texture of the IIC horizon is clay or silty clay loam, and the reaction of this horizon is mildly or moderately alkaline.

Brevort soils are similar to and occur near Breckenridge and Pinconning soils. They have a coarser textured B horizon than Breckenridge soils and a coarser textured IIC horizon than Pinconning soils.

Brevort sandy loam (0 to 2 percent slopes) (Bv).—This nearly level to depressional soil occurs in the eastern part of the county, mainly in the areas where the till plains join the outwash plains and lake plains. It occurs as small, scattered areas in the landscape, along with Kawkawlin, Belding, and Iosco soils.

In places this soil has a 6- to 8-inch subsoil that is finer textured than the subsoil in the typical profile. In other places the underlying material is stratified. Included in mapping were spots of Iosco soils, which are slightly better drained and lighter colored than this Brevort soil; spots of Breckenridge and Sims soils, which do not have sandy material in the uppermost 18 to 42 inches; and spots of Granby soils, which do not have finer textured underlying material within 42 inches of the surface.

The use of this soil is governed by the use of the surrounding soils. Most areas are in fields where crops are grown. Artificial drainage is needed for most crops. Drainage is difficult in many places, and if the water table is lowered too much, the soil becomes droughty and susceptible to blowing. (Capability unit IIIw–10 (4/2c); woodland suitability group W)

Bruce Series

The Bruce series consists of poorly drained soils that occur on lake plains and outwash plains throughout the county. These soils developed in stratified loamy material.

In a typical profile, the surface layer consists of very dark gray loam and is about 6 inches thick. Below this is an 8-inch subsurface layer of gray, mottled silt loam. The subsoil, about 10 inches thick, consists of grayish-brown, mottled, friable light silty clay loam. Light brownish-gray, mottled, stratified silt loam and very fine sandy loam underlie the subsoil at a depth of about 24 inches.

Fertility is medium, the available water capacity is high, and permeability is moderate. Runoff is slow to ponded, and the water table is high. Frost is a hazard to crops. Cleared areas that have been drained artificially are used for crops; those that have not been drained are used for pasture or are idle. Some areas are still wooded. The native vegetation is mainly a mixture of lowland hardwoods, including red maple, elm, ash, and aspen; it also contains a little white pine.

Typical profile of Bruce loam, cultivated, located in the S½SW¼SW¼SW¼ sec. 2, T. 7 N., R. 13 W. (Tallmadge Township):

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam; weak, fine, granular structure; friable; neutral; abrupt, smooth boundary.

A2g—6 to 14 inches, gray (10YR 5/1) silt loam; few, fine, distinct, very dark brown (10YR 2/2) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

Bg—14 to 24 inches, grayish-brown (10YR 5/2) light silty clay loam; many, medium, prominent, light olive-brown (2.5Y 5/6) mottles and common, medium, faint, pale-brown (10YR 6/3) mottles; weak, medium, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary.

Cg—24 to 50 inches, light brownish-gray (10YR 6/2), stratified silt loam and very fine sandy loam; few, fine, faint, light yellowish-brown (10YR 5/4) mottles and common, medium, distinct, light yellowish-brown (10YR 6/4) mottles; weak, medium to coarse, subangular blocky structure; mildly alkaline.

Strata of silty clay, loam, loamy fine sand, and fine sand, 1 to 3 inches thick, occur in both the solum and the substratum in some profiles. The thickness and the sequence of the strata vary within short distances. In reaction the solum ranges from medium acid to mildly alkaline.

In some places a thin layer of black organic matter occurs at the surface.

The texture of the Ap horizon is loam, silt loam, or fine sandy loam, and the color ranges to dark gray (10YR 4/1) or dark grayish brown (10YR 4/2).

The horizons below the Ap horizon are very poorly expressed in some places. In the A2g horizon the color ranges to dark gray (5Y 4/1), gray (10YR 6/1), or grayish brown (10YR 5/2) and the mottles are faint to prominent.

The Cg horizon is neutral or mildly alkaline in reaction.

Bruce soils and Kibbie soils formed in similar material, but Bruce soils are wetter and grayer than Kibbie soils. Bruce soils are in the same drainage class as Hettinger and Sims soils. They have a coarser textured Cg horizon than Hettinger soils, and they differ from Sims soils in having layers of silt loam in the Cg horizon.

Bruce loam (0 to 2 percent slopes) (By).—This nearly level to depressional soil occurs throughout the county, mainly on lake plains but also on outwash plains.

In some places the surface layer is thicker and darker colored than the one in the typical profile. In other places the texture of the surface layer is silt loam or fine sandy loam. Included in mapping were spots of Kibbie soils, which are lighter colored and better drained than this Bruce soil, and spots of Tonkey and Granby soils, which are coarser textured. Also included are a few areas in which the slope is slightly more than 2 percent.

Fertility is medium, and the available water capacity is high. Runoff is slow to ponded, and the water table is high. Artificial drainage is needed for most crops. Installation and maintenance of drainage systems are likely to be difficult.

Many areas have been cleared; some of these are used for crops, and others for pasture. Corn, small grain, and hay are the common crops. (Capability unit IIw–6 (2.5c); woodland suitability group W)

Carlisle Series

The Carlisle series consists of very poorly drained, level to depressional, organic soils that occur on lake plains, on outwash plains, on flood plains, and in pockets and swales on the uplands.

In a typical profile, the surface layer consists of black muck and is about 12 inches thick. Below this is about 8 inches of dark reddish-brown muck, then another 8 inches of black muck. At a depth of about 28 inches is dark reddish-brown, partly decomposed peat that contains some woody fragments, and at 40 inches, dark reddish-brown, undecomposed woody peat.

Natural fertility is low, the available water capacity is high, and permeability is rapid. Runoff is slow to ponded, and water from higher adjacent soils collects. Artificial drainage is needed for most crops.

If drained and carefully managed, Carlisle soils are well suited to special crops, including celery, mint, carrots, and onions. Corn is the main field crop. Artificial drainage is difficult because of the unstable nature of the organic material. Undrained areas are in pasture, mainly of reed canarygrass, or in second-growth woodlots. The native vegetation consists mainly of lowland hardwoods, including elm, ash, and soft maple, but also contains some tamarack, cherry, willow, and white pine.

Typical profile of Carlisle muck, cultivated, located in the N½SE¼NW¼ sec. 10, T. 5 N., R. 14 W. (Zeeland Township):

1—0 to 12 inches, black (N 2/0), well-decomposed muck; moderate, medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

2—12 to 20 inches, dark reddish-brown (5YR 2/2) muck; massive, parting to weak, thick, platy structure; friable; a few small fragments of woody material; medium acid; gradual, wavy boundary.

3—20 to 28 inches, black (5YR 2/1), finely divided muck; massive, parting to weak, medium, subangular blocky structure; friable; many fragments of woody material; medium acid; gradual, wavy boundary.

4—28 to 40 inches, dark reddish-brown (5YR 3/2), partly decomposed fibrous peat; massive; friable; some coarse, undecomposed fragments of woody material; medium acid; gradual, wavy boundary.

5—40 to 60 inches, dark reddish-brown (5YR 2/2), undecomposed woody peat; massive; friable; slightly acid.

The content of woody fragments in the uppermost 24 inches varies widely. The range in reaction is from medium acid to neutral. The various horizons range from 4 to more than 12 inches in thickness.

In some places the surface layer contains some mineral material. The color of the surface layer and the second layer ranges to black (10YR 2/1) or very dark brown (10YR 2/2), and the color of the third layer to dark brown (7.5YR 4/4). The organic material below a depth of 24 inches is generally fibrous or woody peat, but one or more layers may consist of jellylike colloidal peat.

Carlisle soils contain more woody material than Houghton soils. They have thicker deposits of organic material than either Adrian soils, which are underlain with sand, or Edwards soils, which are underlain with marl.

Carlisle muck (0 to 2 percent slopes) (Cc).—This nearly level to depressional soil occurs on lake plains, on outwash plains, on flood plains, and in pockets and swales on the uplands.

In some places the content of woody fragments is greater and the reaction more acid than is typical. In a few places the reaction is extremely acid and the organic material is underlain with marl; one such area is near Hudsonville. In other places the reaction is extremely acid or very strongly acid and the content of fibrous material is greater than is typical; one such area is in Aman Park. Included in mapping were small areas of Adrian soils, which are underlain with sand. On flood plains are included spots of Wallkill soils, which have a mineral overwash.

This soil is highly valued for growing special crops, including celery, onions, mint, carrots, and radishes. Artificial drainage is needed for most crops. Control of the water level is important, because the soil settles if overdrained and also becomes susceptible to blowing. (Capability unit IIIw–15 (Mc); woodland suitability group U)

Ceresco Series

The Ceresco series consists of somewhat poorly drained soils that occur on flood plains, commonly on the natural levees next to the stream. These soils formed in alluvium of loamy fine sand to sandy loam texture.

In a typical profile, the surface layer consists of very dark gray loam and is about 12 inches thick. Below this are a 9-inch layer of brown, mottled, friable sandy loam; a 9-inch layer of grayish-brown, mottled, friable loamy fine sand; and a 10-inch layer of gray, mottled, friable sandy loam.

Fertility is medium, the available water capacity is moderate, permeability is moderately rapid, and runoff is very slow. Flooding is a hazard.

Because of the flood hazard and the somewhat poor drainage, few areas of Ceresco soils are used for crops. Most areas are in native pasture or in woods or are idle. The native vegetation is a mixture of lowland hardwoods, including elm, ash, maple, cottonwood, and some sycamore.

Typical profile of Ceresco loam, undisturbed, located in the NE¼SE¼NE¼ sec. 18, T. 7 N., R. 13 W. (Tallmadge Township):

A1—0 to 12 inches, very dark gray (10YR 3/1) loam; weak, medium, granular structure; friable; neutral; clear, wavy boundary.

C1—12 to 21 inches, brown (10YR 5/3) sandy loam; many, medium, distinct, gray (10YR 5/1) mottles and common, medium, distinct, very dark grayish-brown (10YR 3/2) mottles; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

C2g—21 to 30 inches, grayish-brown (10YR 5/2) loamy fine sand; many, coarse, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, coarse, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C3g—30 to 60 inches, gray (10YR 5/1) sandy loam; common, medium, faint, brown (7.5YR 5/2) mottles; massive; friable; moderately alkaline.

The texture of the A1 horizon is silt loam, loam, fine sandy loam, sandy loam, or loamy fine sand, and the color ranges to very dark grayish brown (10YR 3/2). In some places the profile includes an A2g horizon and a Bg horizon.

The texture of the C horizon is loamy fine sand, sandy loam, or fine sandy loam. Below a depth of 36 inches, the texture is dominantly sandy loam but there are thin layers of silt, silty clay, and sand. The color of the C1 horizon ranges to grayish brown (10YR 5/2) mottled with dark gray (10YR 4/1).

Ceresco soils and Cohoctah soils formed in similar material, but Ceresco soils occur at slightly higher elevations than Cohoctah soils and are better drained. Ceresco soils and Shoals soils are in the same drainage class, but Ceresco soils are coarser textured than Shoals soils.

Ceresco loam (0 to 6 percent slopes) (Ce).—This soil is on flood plains throughout the county. Much of it occurs

as narrow areas on the natural levees, which are next to and parallel to the streams. These areas on the natural levees have long, gentle slopes; the other areas are nearly level.

Included with this soil in mapping were areas of poorly drained Cohoctah and Sloan soils, which are in depressions, sloughs, and ponded areas on the flood plains; small areas of Shoals soils, which are finer textured than this Ceresco soil; and spots of Algansee soils, which are coarser textured.

Fertility is medium, the available water capacity is moderate, permeability is moderately rapid, and runoff is very slow. Farming is difficult because of the flood hazard and a fluctuating water table that limits tillage and interferes with the growth of roots.

Although crops can be grown under careful management, most areas of this soil are in pasture or woods. (Capability unit IIIw–12 (L–2c); woodland suitability group O)

Chelsea Series

The Chelsea series consists of well-drained soils that occur on lake plains, outwash plains, till plains, and moraines. These soils developed in deep deposits of sand stratified below a depth of 42 inches with thin layers of loamy sand or sandy loam.

In a typical profile, the surface layer consists of dark grayish-brown loamy sand and is about 7 inches thick. Below this is a 4-inch subsurface layer of gray sand. The upper 25 inches of the subsoil consists of yellowish-brown, very friable sand over light yellowish-brown, loose sand. Beginning at a depth of 36 inches is a 12-inch layer of pale-brown, loose sand, and below that are alternate layers of yellowish-brown sandy loam and light yellowish-brown sand that extend to a depth of more than 66 inches.

Fertility is low, the available water capacity is low, and permeability is rapid. The growth of plants is slowed in summer by the shortage of moisture. The soils are susceptible to both water erosion and soil blowing.

Chelsea soils are only fairly well suited to crops. Many areas have been cleared and cultivated in the past, but some of these are now idle. Other areas are still wooded. The native vegetation consists mainly of hardwoods, including oak, aspen, hickory, and sugar maple; it also contains some white pine. At one time there were some dense stands of white pine.

Typical profile of Chelsea loamy sand, 0 to 6 percent slopes, cultivated, located in the NE¼SE¼SW¼ sec. 22, T. 7 N., R. 13 W. (Tallmadge Township):

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loamy sand; weak, medium, granular structure; very friable; neutral; abrupt, smooth boundary.

A2—7 to 11 inches, gray (10YR 5/1) sand; weak, medium, granular structure; very friable; medium acid; clear, wavy boundary.

B2ir—11 to 22 inches, yellowish-brown (10YR 5/8) sand; weak, coarse, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B3—22 to 36 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; slightly acid; clear, wavy boundary.

A'2—36 to 48 inches, pale-brown (10YR 6/3) sand; single grain; loose; slightly acid; abrupt, wavy boundary.

B't&A'2—48 to 66 inches, yellowish-brown (10YR 5/8–5/6) sandy loam, representing the B't horizon, and light yellowish-brown (10YR 6/4) sand, representing the A'2 horizon. B't layers are ¼ inch to 2 inches thick and discontinuous; A'2 layers are 3 to 8 inches thick. B't material is massive, friable, and medium acid; boundaries are abrupt and wavy. A'2 material has weak, medium, subangular blocky structure and is very friable and slightly acid.

In undisturbed areas the profile includes a very dark gray (10YR 3/1) or very dark grayish-brown (10YR 3/2) A1 horizon, 2 to 4 inches thick. In places it contains some gravel.

In some places the texture of the A1 or Ap, A2, and B2ir horizons is light loamy sand.

The color of the A2 horizon ranges to gray (10YR 6/1); that of the B2ir horizon to dark brown (7.5YR 4/4) or dark yellowish brown (10YR 4/4); and that of the A'2 horizon to brown (10YR 5/3).

The reaction of the B't&A'2 horizon is slightly acid or neutral. In the B't layers of this horizon, the color ranges to dark yellowish brown (10YR 4/4), dark brown (7.5YR 4/4), or brown (7.5YR 5/4). In places there are B't layers below a depth of 66 inches, but they are thinner and farther apart than those above that depth.

Chelsea soils formed in the same kind of material as Montcalm, Kalkaska, Rubicon, and Croswell soils. Multiple B't horizons, which are characteristic of Chelsea soils, are lacking from the Kalkaska, Rubicon, and Croswell soils but are more numerous and nearer the surface in Montcalm soils than in Chelsea soils. Chelsea soils lack the limy, sandy and gravelly IIC horizon that is characteristic of Mancelona soils, which occur nearby.

Chelsea loamy sand, 0 to 6 percent slopes (ChB).—This soil occurs on lake plains and outwash plains and also on ridgetops and in small level areas on the uplands. The individual areas in the uplands are much smaller than those on the plains.

This soil has the profile described as typical of the series. In some places the surface layer is black and is 2 to 5 inches thick; in some the texture is light loamy sand to a depth of about 18 or 20 inches; and in others the texture in the uppermost 3 feet is dominantly loamy sand and the bands of sandy loam or loamy sand in the lower part are lacking. Included in mapping were eroded spots in which the surface layer is sand and is lighter colored; spots of Rubicon soils, which are sand throughout; and spots of Montcalm soils, which have one thick layer of sandy loam in the subsoil. Also included were areas in which limy gravel occurs deep in the subsoil, and others, mainly near finer textured upland soils, in which clay loam occurs within 66 inches of the surface.

Fertility is low, the organic-matter content is low, and the available water capacity is low. Erosion and soil blowing are hazards where crops are grown.

Most areas of this soil have been cleared and cultivated in the past. Many of the areas once cultivated are now idle and are covered with grass and weeds. Others have been planted to pine for Christmas trees or for timber. Some of the acreage is still used for crops. Cropping systems commonly consist largely of close-growing or early-maturing crops. (Capability unit IVs–4 (5a); woodland suitability group E)

Chelsea loamy sand, 6 to 12 percent slopes (ChC).—This soil is on lake plains, outwash plains, and sandy moraines throughout the country. The slopes are short, and those on the uplands are irregular.

The surface is grayish-brown loamy sand or sand, as a result of the mixing of some subsoil material with the surface layer by plowing. Included in mapping were some severely eroded spots; in these places the surface layer is yellowish-brown sand and the bands of finer textured material are within 3 feet of the surface. Also included were a

few spots in which the surface layer is dark grayish-brown loamy sand and the bands of finer textured material below a depth of 42 inches are thinner and fewer. Small areas were included in which the texture is loamy sand to a depth of 2 or 3 feet and the bands in the lowest layer of the profile are lacking or are distinguishable only by color. Included in mapping were spots of Rubicon soils, which are sandy throughout, and areas in which the slope is less than 6 percent or more than 12 percent.

Fertility is low, and the available water capacity is low. Water erosion and soil blowing are hazards.

Most of this soil has been cleared and cultivated, but many areas once cultivated are now in permanent pasture or have been reforested with pine trees. Some areas are still cultivated. Long cropping systems that consist mainly of meadow crops and small grain are usual. (Capability unit VIs–1 (5a) ; woodland suitability group E)

Chelsea complex, 0 to 6 percent slopes (ClB).—This mapping unit occurs in the western part of the county. About 60 percent of the acreage consists of Chelsea soils, and about 30 percent of Rubicon soils that have a loamy substratum. Most of the rest consists of small areas of other sandy soils.

In most areas the surface layer is dark grayish-brown loamy sand, but in some places this layer is dark-brown loamy sand and the texture throughout is dominantly loamy sand. In some places, mainly in Olive and Crockery Townships, the sandy loam layers are thicker and more numerous than is typical. In some places a continuous fine-textured layer occurs at a depth of 42 to 66 inches. Included in mapping were small eroded spots in which the surface layer is yellowish-brown sand and the layers of sandy loam start at a depth of 42 to 48 inches. Also included were spots of Croswell soils, which are only moderately well drained and are faintly mottled at or below a depth of 20 inches.

Natural fertility is low, the available water capacity is low, and permeability is rapid. The organic-matter content is low. Erosion and soil blowing are hazards.

Most areas of these soils have been cleared and cultivated in the past, but many are now idle and are covered with grass and weeds. Some are used for spring pasture, and some have been reforested with pine for Christmas trees or for timber. A few areas are still wooded. Corn, small grain, and hay are grown in some areas. Cropping systems are generally long and are dominated by close-growing, early-maturing crops. (Capability unit IVs–4 (5a) ; woodland suitability group E)

Cohoctah Series

The Cohoctah series consists of very poorly drained soils on first bottoms. These soils developed in water-deposited sandy loam and loam. They have a high water table and are flooded frequently.

In a typical profile, the surface layer consists of very dark gray loam and is about 13 inches thick. Below this is an 8-inch layer of dark-gray, streaked, friable sandy loam; a 12-inch layer of grayish-brown, mottled, friable fine sandy loam; a 7-inch layer of very dark grayish-brown, mottled, friable sandy loam; and at least 20 inches of grayish-brown, mottled, friable sandy loam.

Fertility is high, the available water capacity is high, permeability is moderate to moderately rapid, and runoff is very slow. The high water table hinders cultivation and restricts the growth of plant roots. The grayish colors result from prolonged saturation.

Few areas of Cohoctah soils are used for crops. Most are in pasture or are idle or still wooded. The native vegetation is a mixture of lowland hardwoods, including elm, ash, maple, cottonwood, and sycamore.

Typical profile of Cohoctah loam, undisturbed, located in the SE¼SE¼SW¼ sec. 22, T. 7 N., R. 13 W. (Tallmadge Township) :

A1—0 to 13 inches, very dark gray (10YR 3/1) loam; weak, medium, granular structure; friable; mildly alkaline; clear, smooth boundary.

C1g—13 to 21 inches, dark-gray (10YR 4/1) sandy loam; many, medium, distinct, very dark brown (10YR 2/2) vertical streaks; weak, coarse, subangular blocky structure; friable; moderately alkaline; clear, smooth boundary.

C2g—21 to 33 inches, grayish-brown (10YR 5/2) fine sandy loam; many, fine, distinct, yellowish-red (5YR 5/6) mottles; weak, coarse, subangular blocky structure, grading to massive; friable; moderately alkaline; abrupt, smooth boundary.

C3g—33 to 40 inches, very dark grayish-brown (10YR 3/2) loam; few, fine, prominent, gray (10YR 5/1) mottles; massive; friable; moderately alkaline; abrupt, wavy boundary.

C4g—40 to 60 inches, grayish-brown (10YR 5/2) sandy loam; common, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, coarse, subangular blocky structure; friable; moderately alkaline.

The horizons and the strata within the horizons vary in thickness and in texture. The dominant range in texture is from loam to loamy fine sand, but thin layers of fine sand and silt loam occur in some areas. The range in reaction is from slightly acid to moderately alkaline.

In cultivated areas there is an Ap horizon that is 7 to 10 inches thick, The texture of this layer is loam, sandy loam, silt loam, or loamy fine sand, and the color ranges to black (10YR 2/1) or very dark grayish brown (10YR 3/2). The structure is weak or moderate granular. Below the Ap horizon in this area is a 3- to 8-inch A1 horizon that is very dark gray (10YR 3/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2).

The color of the Cg horizon has a hue of 10YR, a value of 3, 4, 5, or 6, and a chroma of 1 or 2. The mottles in this horizon range from faint to prominent.

Cohoctah soils formed in the same kind of material as Ceresco soils, which occur nearby, but Cohoctah soils are more poorly drained than Ceresco soils and are grayer throughout. Ceresco soils are more poorly drained and generally coarser textured than Sloan soils.

Cohoctah loam (0 to 2 percent slopes) (Cm).—This soil occurs throughout the county, on first bottoms that are mainly nearly level but include slight depressions and slight elevations.

The surface layer of this soil is very dark gray or black and is 10 to 15 inches thick. Floods often deposit new material of various colors and textures. Some areas are not easily accessible. Included in mapping were spots of finer textured Sloan soils, which occupy many of the slight depressions, and of better drained Ceresco soils, which occupy many of the slightly elevated areas.

Fertility is high, and the available water capacity is high. Drainage is very poor, and installing artificial drainage facilities is difficult. Floods are frequent, and frost is a hazard to crops.

Many areas of this soil are still wooded, and many are used for native pasture. Corn and hay are the main crops grown. (Capability unit IIIw–12 (L–2c) ; woodland suitability group O)

Conover Series

The Conover series consists of somewhat poorly drained soils that occur on till plains in the southeastern part of the county.

In a typical profile, the surface layer consists of very dark grayish-brown loam and is about 8 inches thick. The subsoil is about 21 inches thick. The upper 5 inches consists of pale-brown, mottled, firm loam, and the lower 16 inches of yellowish-brown and grayish-brown, mottled, firm clay loam. The underlying material, at a depth of 29 inches, is light brownish-gray, mottled, limy heavy loam; it extends to a depth of at least 60 inches.

Fertility is high, the available water capacity is high, permeability is moderate, and runoff is slow. Erosion is a hazard.

Most areas of these soils are cleared and cultivated. Corn, small grain, and hay are the main crops. Very little of the acreage is wooded. The native vegetation includes hard maple, soft maple, beech, red oak, hickory, and some basswood.

Typical profile of Conover loam, 2 to 6 percent slopes, cultivated, located in the NE¼SE¼NE¼NW¼ sec. 14, T. 5 N., R. 14 W. (Zeeland Township):

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam; moderate, medium, granular structure, friable; neutral; abrupt, smooth boundary.

B1—8 to 13 inches, pale-brown (10YR 6/3) loam; common, medium, distinct, yellowish-brown (10YR 5/8) mottles and few, medium, distinct, light brownish-gray (10YR 6/2) mottles; moderate, medium, subangular blocky sturcture; firm; very strongly acid; gradual, wavy boundary.

B21t—13 to 23 inches, yellowish-brown (10YR 5/4) clay loam; many, medium, distinct, yellowish-brown (10YR 5/8) and few, medium, distinct, light-gray (10YR 7/2) mottles; strong, medium, subangular blocky structure; firm; light brownish-gray (10YR 6/2) clay films on ped faces; strongly acid; gradual, wavy boundary.

B22tg—23 to 29 inches, grayish-brown (10YR 5/2) clay loam; common, medium, distinct, yellowish-brown (10YR 5/4) mottles; strong, coarse, subangular blocky structure; firm; slightly acid; clear, wavy boundary.

Cg—29 to 60 inches, light brownish-gray (10YR 6/2) heavy loam; common, medium, distinct, brown (10YR 5/3) mottles; moderate, medium, subangular blocky structure; firm; vertical streaks of lime are grayish brown (10YR 5/2); calcareous.

The solum is 20 to about 42 inches thick. In reaction it ranges from very strongly acid to neutral, but it is dominantly medium acid.

In undisturbed areas the profile includes an A1 and A2 horizon, each 3 to 6 inches thick. The color of the A1 horizon is very dark gray (10YR 3/1), and that of the A2 is grayish brown (10YR 5/2) or brown (10YR 5/3). An A2 horizon as much as 4 inches thick also occurs in some cultivated areas. Profiles that have an A2 horizon generally lack a B1 horizon.

In the Ap horizon the color ranges to very dark brown (10YR 2/2) or very dark gray (10YR 3/1).

The texture of the B2t horizon is clay loam or silty clay loam. The color of this horizon ranges to grayish brown (10YR 5/2), brown (10YR 5/3–4/3), yellowish brown (10YR 5/6), or dark yellowish brown (10YR 4/4).

The texture of the C horizon is loam, heavy loam, or light clay loam. The color of this horizon ranges to grayish brown (10YR 5/2) or brown (10YR 5/3).

Conover soils occur near Sims soils and Metamora soils. They are better drained than Sims soils, and they have a finer textured B2t horizon than Metamora soils. Conover soils are in the same drainage class as Kibbie soils, but they lack the layers of silt and very fine sand in the C horizon that are characteristic of Kibbie soils.

Conover loam, 2 to 6 percent slopes (CnB).—This soil occurs on gently undulating till plains in the southeastern part of the county. Some areas have long, uniform slopes; others have short, irregular slopes dissected with depressions and shallow drainageways.

Included in mapping were areas of poorly drained Sims soils in the depressions and drainageways; of well-drained Miami soils at slightly higher elevations; and of coarser textured Metamora soils. Also included were eroded ridgetops where the surface layer is brown or dark grayish brown. In places the texture of the underlying material is clay loam.

Fertility is high, and the available water capacity is high. Natural drainage is somewhat poor, and artificial drainage is needed. Erosion is a hazard.

Most areas of this soil are used for crops, mainly corn, small grain, and hay. (Capability unit IIw–3 (2.5b); woodland suitability group Z)

Croswell Series

The Croswell series consists of moderately well drained soils of the sandy outwash plains and lake plains. These soils developed in deep deposits of acid sand.

In a typical profile, the surface layer consists of very dark brown sand and is only about 2 inches thick. Below this is a 6-inch subsurface layer of gray sand. The subsoil, about 16 inches thick, consists of very friable sand. It is dark brown in the upper 6 inches and dark yellowish brown and mottled in the lower 10 inches. The underlying material, at a depth of 24 inches, is light yellowish-brown, mottled sand; it extends to a depth of at least 60 inches.

Fertility is low, the organic-matter content is low, and the available water capacity is low. Permeability is rapid above the fluctuating water table. These soils are saturated during periods of rainy weather. The upper part of the profile dries out quickly after the rain stops, but the part below a depth of 36 inches remains wet. The soils erode and blow readily if exposed.

Only a few areas of Croswell soils are cultivated. Many areas that were cultivated in the past are now idle or are used for supplemental pasture. Other areas once cultivated have been reforested with pine for Christmas trees or for timber. Some areas are second-growth woodlots. The native vegetation is mainly a mixture of hardwoods and white pine but includes some hemlock.

Typical profile of Croswell sand, 0 to 6 percent slopes, undisturbed, located in the NW¼NE¼SE¼ sec. 6, T. 7 N., R. 14 W. (Allendale Township):

A1—0 to 2 inches, very dark brown (10YR 2/2) sand; weak, fine, granular structure; very friable; very strongly acid; abrupt, wavy boundary.

A2—2 to 8 inches, gray (10YR 5/1) sand; weak, coarse, subangular blocky structure; very friable; very strongly acid; clear, irregular boundary.

B21ir—8 to 14 inches, dark-brown (7.5YR 4/4) sand; weak, coarse, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

B22ir—14 to 24 inches, dark yellowish-brown (10YR 4/4) sand; many, medium, distinct, grayish-brown (10YR 5/2) mottles; weak, coarse, subangular blocky structure; very friable; strongly acid; gradual, wavy boundary.

C—24 to 60 inches, light yellowish-brown (10YR 6/4) sand; common, medium, distinct, grayish-brown (10YR 5/2) mottles; single grain; loose; medium acid.

In cultivated areas there is a 6- to 10-inch Ap horizon that is very dark grayish brown (10YR 3/2) or dark gray (10YR

4/1). Where the Ap horizon is almost at its maximum thickness, the A2 horizon is very thin or lacking.

The texture of the A1 horizon is sand or loamy sand, and the color ranges to very dark gray (10YR 3/1). The texture of the A2 horizon is sand or light loamy sand, and the color ranges to light gray (10YR 6/1) or light brownish gray (10YR 6/2).

The color of the B21ir horizon ranges to dark yellowish brown 10YR 4/4) or reddish brown (5YR 4/4), and that of the B22ir horizon to dark brown (7.5YR 4/4). The depth to mottling ranges from about 14 to 24 inches. The mottles have a hue of 10YR, a value of 5 or more, and a chroma of 2 or less. In a few places the profile contains small chunks of ortstein, and in some places the lower part of the subsoil contains a little dark reddish-brown (2.5YR 3/4), shotlike cemented material.

Croswell soils, Rubicon soils, and Au Gres soils all formed in similar material. Croswell soils differ from Rubicon soils in having mottles in the B22ir horizon and from Au Gres soils in being moderately well drained instead of somewhat poorly drained.

Croswell sand, 0 to 6 percent slopes (CrB).—This soil is on lake plains and outwash plains in the eastern section of the county. The areas range in size from a few acres to more than 100 acres. Most are fairly large.

This soil has the profile described as typical of the series. In some areas the texture of the surface layer is loamy sand instead of sand. Included in mapping were spots of well-drained Rubicon soils and of somewhat poorly drained Au Gres soils. Also included, mostly where the plains grade into the uplands, were spots in which a fine-textured substratum occurs at a depth of 42 inches. Other inclusions are blow-outs and other eroded areas.

Fertility is low, and the available water capacity is low. The soil erodes and blows readily.

This soil is not well suited to crops, and only a few areas are cultivated. Most areas are idle or have been reforested with pine. (Capability unit IVs-4 (5a); woodland suitability group E)

Croswell and Au Gres sands, 0 to 6 percent slopes (CwB).—This unit occurs on sandy plains in the western part of the county. Croswell sand predominates in some areas, and Au Gres sand in other.

Both soils have a fluctuating water table that rises during prolonged periods of rainy weather. The water table rises closer to the surface in Au Gres soils than in Croswell soils, and as a result Au Gres soils are mottled closer to the surface. Both soils have a thicker, darker colored surface layer in undisturbed areas than in eroded areas.

These soils are low in fertility and in organic-matter content. They are wet in spring and dry in summer. When bare they erode easily and are susceptible to blowing.

Most large areas of this unit have been cleared and were cultivated at one time. Many are now idle and are covered with weeds and grass and scattered quaking aspen, fire cherry, and scrub oak. Other areas have been reforested with pine intended for Christmas trees or for timber. Only a few areas are now cultivated. (Capability unit IVs-4 (Croswell—5a, Au Gres—5b); Croswell soil in woodland suitability group E, Au Gres soil in woodland suitability group F)

Deer Park Series

The Deer Park series consists of well-drained soils that occur on stabilized dunes and beach ridges along the shore of Lake Michigan and on older stabilized dunes as far inland as Crockery, Robinson, and Olive Townships. These soils developed in slightly acid, loose sand.

In a typical profile, a 2-inch layer of black organic material is at the surface. Below the organic material is a 1-inch layer of very dark gray sand and then a 10-inch layer of pale-brown sand. The subsoil, about 7 inches thick, consists of light yellowish-brown, loose sand. At a depth of about 18 inches is pale-brown sand; this extends to a depth of at least 66 inches.

Fertility is very low, the available water capacity is very low, and permeability is rapid. If the native vegetation is removed, these soils start to blow and are very difficult to stabilize again.

Deer Park soils are not suitable for farming, but they have esthetic and recreational values as cottage sites, parks, and scenic wooded areas. The native vegetation in the areas nearest the lake, where the climate is tempered somewhat, consists of a dense growth of beech, maple, red oak, white pine, and hemlock. In areas more than a quarter of a mile inland, the vegetation is a mixture of hardwoods and conifers that includes white oak, black oak, aspen, and white pine. Some of the inland areas once supported nearly pure stands of white pine.

Typical profile of Deer Park sand, 6 to 18 percent slopes, undisturbed, on a 15-percent lee slope of a wooded fore dune, located in the SE¼NE¼NE¼ sec. 1, T. 8 N., R. 17 W. (Spring Lake-West Township):

O2—2 inches to 0, black (10YR 2/1) organic mat; a few light yellowish-brown (10YR 6/4) sand grains intermixed; single grain; friable; slightly acid; abrupt, smooth boundary.

A1—0 to 1 inch, very dark gray (10YR 3/1) sand; light yellowish-brown (10YR 6/4) sand grains intermixed give horizon a "salt and pepper" appearance; single grain; loose; medium acid; clear, wavy boundary.

A2—1 to 11 inches, pale-brown (10YR 6/3) sand; single grain; few, fine, faint, gray (10YR 6/1) organic stains in uppermost 3 inches; loose; medium acid; gradual, wavy boundary.

Bir—11 to 18 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid; gradual, wavy boundary.

C—18 to 66 inches, pale-brown (10YR 6/3) sand; single grain; loose; slightly acid.

In some profiles the reaction ranges to mildly alkaline below a depth of 3 feet.

The A1 horizon is lacking from the profile in some places, and the A2 horizon is immediately below the O2 horizon. In the A2 horizon the color ranges to light gray (10YR 6/1), light brownish gray (10YR 6/2), or gray (10YR 5/1).

The Bir horizon is weakly expressed and in places is not readily distinguishable. The color of this horizon ranges to yellowish brown (10YR 5/4) or brown (10YR 5/3).

Deer Park soils and Rubicon soils formed in similar material, but Deer Park soils have a lighter colored and less well developed Bir horizon than Rubicon soils.

Deer Park sand, 0 to 6 percent slopes (DpB).—This soil occurs as small stable areas within steeper areas in the dunes along Lake Michigan. Some areas are on the saddles between dunes, some are on the crests of dunes, and some are on the lower slopes. Most areas are within a quarter of a mile of the lake, but some are as far inland as Crockery, Robinson, and Olive Townships.

In disturbed spots the surface layer is pale brown. There are small areas in which the organic mat is more than 2 inches thick and others that have an overburden of windblown light yellowish-brown or pale-brown sand 1 to 4 inches thick. Included in mapping were soils that have a brighter colored subsoil. In some of the inland areas, the soil is similar to Rubicon soils.

This Deer Park soil is very low in fertility and in available water capacity. It is highly susceptible to blowing if the vegetation is removed, and it is difficult to stabilize once it has started to blow.

This soil is highly valued for cottage sites. Access to some areas is difficult. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Deer Park sand, 6 to 18 percent slopes (DpD).—This soil occurs as stable areas on the sides and lee slopes of dunes and beach ridges along Lake Michigan and on stabilized dunes farther inland. Nearly all the areas are within a quarter of a mile of the lake, but some are as far inland as Crockery, Robinson, and Olive Townships.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. In places the pale-brown sand is at the surface. In many of the inland areas, this soil is similar to the Rubicon soils.

This Deer Park soil is very low in fertility and in available water capacity. It is highly susceptible to erosion if the vegetation is removed.

This soil is not suitable for farming, but it has esthetic and recreational values. Most of the areas along the lake are covered with a forest of beech, maple, red oak, white pine, and hemlock. Other areas are covered with beachgrass and briers. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Deer Park sand, 18 to 45 percent slopes (DpF).—This soil is on dunes and beach ridges. Nearly all areas are within a quarter of a mile of Lake Michigan, but some are as far inland as Crockery, Robinson, and Olive Townships.

The light yellowish-brown subsoil is lacking from the profile of this soil, and the organic mat at the surface is lacking or is very thin. In some places the pale-brown underlying material is at the surface. Included are areas in which the slope is less than 18 percent. In the inland areas this soil resembles Rubicon soils.

This Deer Park soil is very low in fertility and in available water capacity. It is highly susceptible to blowing if the vegetation is removed.

This soil is not suitable for farming, but it will support a dense forest and has esthetic and recreational values. Much of the acreage is covered with a forest of beech, maple, red oak, white pine, and hemlock. Some has a cover of beachgrass and briers. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Edwards Series

The Edwards series consists of very poorly drained, level to depressional, organic soils that occur on flood plains and on uplands. These soils are underlain with marl at a depth of 12 to 42 inches.

In a typical profile, the surface layer consists of well-decomposed black muck and is about 12 inches thick. Below this is an 18-inch layer of partly decomposed, black mucky peat that contains some dark reddish-brown woody fragments. The underlying material, at a depth of 30 inches, consists of light-gray marl; it extends to a depth of at least 60 inches.

Fertility is low, and the available water capacity is high. Permeability is rapid in the organic layers and is variable in the marl. Runoff is very slow to ponded, and water from surrounding areas runs onto these soils. The water table is at or very near the surface unless lowered by artificial drainage. Drainage is difficult, and overdrainage can cause settling and decomposition and make the soils susceptible to blowing. Frost damage to crops is a hazard.

Many areas have been cleared and drained and are used to grow special crops, including celery, onions, and carrots. Crops need special mixtures of fertilizer. Some areas are still wooded. The native vegetation consists of lowland hardwoods, including elm, ash, red maple, and cottonwood; the stands also contain northern white-cedar. Trees grow slowly and are shallow rooted.

Typical profile of Edwards muck, cultivated, located in the SW¼SW¼SE¼ sec. 33, T. 5 N., R. 13 W. (Jamestown Township):

1—0 to 12 inches, black (10YR 2/1), well-decomposed muck; moderate, fine, granular structure; friable; medium acid; abrupt, wavy boundary.

2—12 to 30 inches, black (5YR 2/1), partly decomposed mucky peat; moderate, fine, granular structure; friable; contains some woody fragments that are dark reddish brown (5YR 3/2); neutral; abrupt, smooth boundary.

IIC—30 to 60 inches, light-gray (10YR 6/1) marl; yellowish-red (5YR 4/6) root channels; massive; nonplastic; highly calcareous.

The depth to marl ranges from 12 to 42 inches. The reaction of the organic layers ranges from medium acid to mildly alkaline. Both woody and fibrous materials are included. The color depends on the nature of the original material. The hue is predominantly 10YR to 5YR, the value 2 or 3, and the chroma 1, 2, or 3. The color of the marl varies but is predominantly light gray (10YR 6/1 or 2.5Y 7/2).

Edwards soils are similar to Carlisle, Houghton, Adrian, and Warners soils. In Edwards soils, the organic deposit is between 12 and 42 inches thick; in Carlisle and Houghton soils, it is more than 42 inches thick; and in Warners soils, it is less than 12 inches thick. Edwards soils are underlain with marl, and Adrian soils with sand.

Edwards muck (0 to 2 percent slopes) (Ed).—This soil occurs in nearly level areas and depressions on flood plains and in potholes and depressions on uplands.

In some places, mainly where this soil grades to more strongly sloping soils on uplands, there is a 6- to 12-inch overwash of very dark gray to dark grayish-brown mineral material. Included in mapping were spots that have been damaged by soil blowing; in these spots the surface layer includes small chunks of grayish marl. Near Hudsonville is a small included area in which mineral material is mixed with the organic material and the texture of the surface layer is silt loam.

A unique area in the vicinity of Hudsonville was also mapped as part of this unit. In this area the organic material is extremely acid and contains calcium sulfate crystals; in certain lights, the surface appears to be covered with small pieces of broken glass. Highly calcareous marl occurs at a depth of 18 to 36 inches, and in places there is sand below the marl at a depth of 42 to 48 inches.

Fertility is low, and the available water capacity is high. Drainage is needed for most crops. Installing drainage facilities is difficult, and overdrainage can cause settling and decomposition. Blowing is a hazard when the soil is dry and exposed.

Most areas of this soil are used for crops or pasture. A few small areas in upland depressions are wooded. Onions, carrots, and celery are grown, as well as corn and forage crops. (Capability unit IVw–6 (M/mc); woodland suitability group U)

Fox Series

The Fox series consists of well-drained soils that occur on outwash plains, deltas, terraces, and rolling uplands. These soils are underlain at a depth of about 38 inches with coarse sand and gravel.

In a typical profile, the surface layer consists of dark-brown sandy loam and is about 7 inches thick. The subsoil is about 31 inches thick. The uppermost 5 inches is yellowish-brown, friable heavy loamy sand; the next 8 inches is dark-brown, friable heavy sandy loam; and the lowest 18 inches is reddish-brown, firm gravelly sandy clay loam. The underlying material, at a depth of 38 inches, is light yellowish-brown coarse sand and gravel.

Fertility is medium, the available water capacity is moderate, and permeability is moderate. Runoff is slow to medium, depending on the slope. Erosion and blowing are hazards if the soil is exposed.

Fox soils are moderately well suited to crops, and most of the acreage is cultivated. Some of it is in orchards. Some areas formerly cultivated are now idle, and some have been converted to building sites. Some areas are sources of sand and gravel. A few are still wooded. The native vegetation is mainly a mixture of hardwoods, including beech, hard maple, oak, hickory, and largetooth aspen; it also contains some white pine.

Typical profile of Fox sandy loam, 0 to 6 percent slopes, cultivated, located in the SW¼NW¼NW¼ sec. 14, T. 5 N., R. 13 W. (Jamestown Township):

Ap—0 to 7 inches, dark-brown (10YR 4/3) sandy loam; weak, fine, granular structure; friable; medium acid; abrupt, smooth boundary.

B1—7 to 12 inches, yellowish-brown (10YR 5/4) heavy loamy sand; weak, coarse, subangular blocky structure; friable; strongly acid; clear, irregular boundary.

B21t—12 to 20 inches, dark-brown (7.5YR 4/4) heavy sandy loam; weak, medium, subangular blocky structure; friable; medium acid; clear, irregular boundary.

B22t—20 to 38 inches, reddish-brown (5YR 4/4) gravelly heavy sandy clay loam; weak, medium, subangular blocky structure; firm; abrupt, irregular boundary.

IIC—38 to 60 inches, light yellowish-brown (10YR 6/4) coarse sand and gravel; single grain; loose; neutral.

The solum is 24 to 42 inches thick. It contains pebbles and cobblestones in varying amounts.

In undisturbed areas the profile includes a dark-gray (10YR 4/1) A1 horizon that is 3 to 6 inches thick. The texture of this horizon is loamy sand, sandy loam, or loam. In some places there is a thin A2 horizon that has a texture range of loamy sand to loam and a color range of light yellowish brown (10YR 6/4) to brown (10YR 5/3).

The texture of the Ap horizon is loamy sand, sandy loam, or loam.

In some places the profile lacks a B1 horizon. The texture of the B21t horizon is sandy loam or sandy clay loam, and the color ranges to yellowish brown (10YR 5/4). In the B22t horizon, the texture is gravelly sandy clay loam or gravelly heavy clay loam, and the color ranges to dark brown (7.5YR 4/4) or dark reddish brown (5YR 3/4).

In some places the profile includes a B3 horizon of gravelly sandy loam or gravelly loamy sand. Tongues of B material, more than 12 inches wide in some places, commonly extend into the IIC horizon.

The reaction of the IIC horizon ranges from neutral to moderately alkaline.

Fox soils, Boyer soils, and Oshtemo soils all formed in similar material. Fox soils have a thicker B2t horizon than Boyer and Oshtemo soils. Fox soils and Hillsdale soils are in the same drainage class, but Hillsdale soils lack the sandy and gravelly IIC horizon that is characteristic of Fox soils.

Fox sandy loam, 0 to 6 percent slopes (FoB).—This soil occurs as small, scattered areas on outwash plains and on rolling uplands.

In places the texture of the surface layer is loam instead of sandy loam, and in places the color is very dark grayish brown instead of dark brown. Included in mapping were small areas of Boyer soils, which are coarser textured and lighter colored than this Fox soil. Other inclusions are areas in which the reaction is more acid and the depth to the gravelly substratum is more than 42 inches, and areas in which the slope is slightly more than 6 percent and the surface layer is eroded and lighter colored.

Fertility is medium. The available water capacity is moderate, and the shortage of moisture is especially noticeable in July, in August, and in the early part of September. The soil blows readily when exposed. Maintenance of the organic-matter content is a problem if crops are grown.

Most areas of this soil have been cleared and cultivated. Corn, small grain, and hay are the common crops. Some areas formerly cultivated are now idle or are in grass. Sand and gravel are extracted from some areas. Limitations for construction are slight. (Capability unit IIs–2 (3a); woodland suitability group K)

Gilford Series

The Gilford series consists of poorly drained and very poorly drained soils that occupy lake plains, outwash plains, glacial drainageways, and deltas. These soils developed in sandy loam and loamy sand material that was 18 to 40 inches thick over stratified sand and gravel.

In a typical profile, the surface layer consists of black sandy loam and is about 12 inches thick. The subsoil is 19 inches thick. The uppermost 3 inches is grayish-brown, mottled and streaked, friable loamy sand; the next 4 inches is brown, mottled, friable loamy sand; and the lowest 12 inches is dark-gray, mottled, friable sandy loam. The underlying material, at a depth of 31 inches, is gray sand and gravel; it extends to a depth of at least 66 inches.

Fertility is medium, and the available water capacity is low. Runoff is very slow or ponded. The water table is near the surface much of the time. The dull grayish colors are the result of prolonged saturation. The growth of plant roots is limited by the water table, and frost damage to crops is a hazard. Permeability is moderate if the water table is lowered.

Many areas of Gilford soils have been cleared and are cultivated. Other areas are used for pasture or are idle. Some swampy woodlots exist, but trees grow slowly and are generally of low quality. The native vegetation is a mixture of hardwoods, including elm, ash, red maple, cottonwood, and some white birch.

Typical profile of Gilford sandy loam, cultivated, located in the SW¼SW¼ sec. 27, T. 6 N., R. 13 W. (Georgetown Township, 300 feet north of Van Buren Street, on 22nd Avenue):

Ap—0 to 10 inches, black (10YR 2/1) sandy loam; moderate fine, granular structure; friable; high in organic-matter content; slightly acid; clear, smooth boundary.

A1—10 to 12 inches, black (N 2/0) sandy loam; moderate, medium, subangular blocky structure; friable; high in organic-matter content; slightly acid; abrupt, smooth boundary.

B21g—12 to 15 inches, grayish-brown (2.5Y 5/2) loamy sand; many, medium, distinct, brown (10YR 5/3) mottles;

many vertical streaks of black (10YR 2/1); weak, coarse, subangular blocky structure; friable; medium acid; clear, wavy boundary.

B22—15 to 19 inches, brown (10YR 5/3) loamy sand; many, medium, distinct, very dark grayish-brown (10YR 3/2) mottles and few, medium, faint, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; medium acid; gradual, wavy boundary.

B23g—19 to 31 inches, dark-gray (5Y 4/1) sandy loam; many, coarse, faint, olive-gray (5Y 4/2) mottles; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

IICg—31 to 66 inches, gray (5Y 5/1) sand and gravel; single grain; loose; mildly alkaline.

The thickness of the solum ranges from 18 to 40 inches but is dominantly between 24 and 36 inches. The reaction ranges from medium acid to neutral.

In undisturbed areas the profile includes a black (10YR 2/1) or very dark gray (10YR 3/1) A1 horizon that is 7 to 12 inches thick. A layer of muck 4 to 12 inches thick is at the surface in some places, and in others stones occur at the surface.

The color of the Ap horizon ranges to very dark gray (10YR 3/1).

The B21g horizon contains varying amounts of gravel. The texture is sandy loam or loamy sand, and the color ranges to gray (10YR 5/1) or grayish brown (10YR 5/2). In some profiles this horizon is unmottled. In the B22 and B23g horizons, the texture ranges from heavy gravelly loamy sand to light sandy clay loam. Where the texture is light sandy clay loam, the combined thickness of these horizons is less than 6 inches.

In places the IICg horizon is dominantly coarse sand. In reaction this layer ranges from neutral to moderately alkaline.

Gilford soils are similar in drainage to Bruce and Granby soils. Gilford soils have a sandy and gravelly IICg horizon; Bruce soils have layers of silt loam in the Cg horizon. Gilford soils have a B2 horizon; Granby soils do not.

Gilford sandy loam (0 to 2 percent slopes) (Gd).—This nearly level to depressional soil occurs on outwash plains and lake plains and in glacial drainageways. Some of the areas on plains and in drainageways are fairly large.

Included in mapping were areas in the eastern and southeastern parts of the county in which the profile is somewhat different from the one described as typical. In some places, mainly in the southeastern part, the surface layer is loam or loamy sand instead of sandy loam, the subsoil and underlying material are more acid, and the underlying material is at a depth of more than 42 inches and is medium acid in reaction. Also in the eastern part of the county are areas in which the sandy and gravelly substratum is lacking, the texture of the subsoil and substratum is predominantly fine sand or loamy fine sand, and the texture of the surface layer is loam or loamy fine sand. Other spots included in mapping are some that have a finer textured subsoil and some in which a thin layer of muck or peat is buried within the profile. Areas of Gladwin soils occur on slight elevations in the landscape, and areas of Granby soils in sandy spots.

This Gilford soil is medium in fertility and low in available water capacity. Runoff is very slow or ponded. The water table is high much of the time. Permeability is moderate if the water table is lowered. Installation and maintenance of artificial drainage systems are difficult, and overdrainage can be damaging. Frost damage to crops is a hazard.

Most areas of this soil have been cleared and drained and are cultivated. The common field crops are grown and also, on selected sites, special crops, including pickling cucumbers, melons, and vegetables. Undrained areas are used mainly for pasture; some are idle. Some areas are still wooded, but trees grow slowly and are shallow rooted. This soil is also a potential source of gravel and sand. (Capability unit IIIw–6 (4c); woodland suitability group W)

Gladwin Series

The Gladwin series consists of somewhat poorly drained soils that occur on outwash plains, terraces, and deltas.

In a typical profile, the surface layer consists of very dark gray sandy loam and is about 7 inches thick. Below this is a 4-inch subsurface layer of gray, mottled loamy sand. The subsoil is 15 inches thick. The upper 6 inches is dark-brown, mottled, friable loamy sand, and the lower 9 inches is dark yellowish-brown, mottled, friable gravelly sandy loam. The underlying material, at a depth of 26 inches, is light brownish-gray, mottled, limy coarse sand and gravel; it extends to a depth of several feet.

Gladwin soils are low in natural fertility, have a low available water capacity, and are moderately permeable. They have a fluctuating water table that rises in spring and recedes in summer. The mottles in the subsoil indicate excessive wetness for part of the year. Runoff is slow to very slow.

Many areas of these soils have been cleared and drained and are used for crops. Cropping systems commonly consist largely of small grain and hay. Some areas are idle or are used for pasture. Others are still wooded. The native vegetation consists mainly of hardwoods, including red maple, sugar maple, ash, oak, and birch; it also contains some white pine. Sand and gravel are obtained from some areas.

Typical profile of Gladwin sandy loam, 0 to 2 percent slopes, cultivated, located in the SW¼SW¼NE¼ sec. 29, T. 5 N., R. 14 W. (Zeeland Township):

Ap—0 to 7 inches, very dark gray (10YR 3/1) sandy loam; weak, medium, granular structure; friable; medium acid; abrupt, smooth boundary.

A2—7 to 11 inches, gray (10YR 5/1) loamy sand; common, medium, distinct, very dark grayish-brown (10YR 3/2) mottles and few, medium, distinct, strong-brown (7.5YR 5/8) mottles; weak, medium, subangular blocky structure; friable; medium acid; clear, irregular boundary.

Bir—11 to 17 inches, dark-brown (7.5YR 4/4) loamy sand; common, medium, distinct, olive-brown (2.5Y 4/4) mottles and few, fine, prominent, brown (10YR 5/3) mottles; weak, coarse, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B't—17 to 26 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam; common, medium, distinct, grayish-brown (10YR 5/2) and pale-brown (10YR 6/3) mottles; weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC—26 to 60 inches, light brownish-gray (10YR 6/2) coarse sand and gravel; common, coarse, faint, brown (10YR 5/3) mottles; single grain, loose; calcareous.

The solum is 18 to 40 inches thick. In reaction it ranges from strongly acid to neutral, becoming less acid with increasing depth. Varying amounts of gravel occur within the solum, and in a few places the Ap horizon contains some cobblestones.

In undisturbed areas the profile includes a 2- to 4-inch A1 horizon that has a texture of sandy loam or loamy sand and is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) in color.

The texture of the Ap horizon is sandy loam or loamy sand. The A2 horizon ranges in color to gray (10YR 6/1) or light brownish gray (10YR 6/2). In some places it is unmottled.

In the Bir horizon the matrix color ranges to dark yellowish brown (10YR 4/4), and the mottles are faint to prominent. The texture of this horizon is light sandy loam or loamy sand. Below the Bir in some profiles is an A'2 horizon that is gray (10YR 5/1) or grayish brown (10YR 5/2) and mottled. The

matrix color of the B't horizon ranges to grayish brown (10YR 5/2) or brown (10YR 5/3). The texture of this horizon is heavy sandy loam, gravelly sandy loam, or gravelly light clay loam.

The upper part of the IIC horizon is neutral to moderately alkaline in reaction. The lower part is calcareous.

Gladwin soils formed in the same kind of material as Mancelona and Gilford soils, which occur nearby. Gladwin soils are less well drained than Mancelona soils and have more gray mottles; they are better drained and less gray than Gilford soils. Gladwin soils are in the same drainage class as Kibbie soils, which lack the sandy and gravelly IIC horizon that is characteristic of Gladwin soils.

Gladwin sandy loam, 0 to 2 percent slopes (GeA).—This soil occurs on outwash plains and on low terraces along streams on the uplands. It is associated with Gilford and Lacota soils, which are in lower positions and are more poorly drained, and with Mancelona and Montcalm soils, which are better drained.

This soil has the profile described as typical of the Gladwin series. Included in mapping were areas in the southeastern part of the county in which the reaction is more acid than is typical and the depth to the underlying material is more than 40 inches. In other included areas in the southeastern part of the county, the surface layer is thicker than is typical, the upper part of the subsoil is yellowish brown, and the subsoil is very strongly acid in places. In other areas limy clay loam occurs at a depth of 40 to 66 inches, and the sandy and gravelly layer is thin and is less alkaline than is typical; most of these areas are where the plains and uplands meet. Included also were small areas in depressions and waterways in which the surface layer is thicker and darker colored than that in the typical profile; spots in which the dark-brown subsoil is exposed as a result of erosion; and gently sloping areas.

Fertility is medium, and the available water capacity is low. The fluctuating water table causes the soil to be excessively wet at some times and droughty at others. Drainage is needed for most crops. After prolonged periods of dry weather, the soil blows readily.

Most areas of this soil have been cleared and cultivated. Corn, small grain, and hay are the common crops. Some areas are idle, some are used for pasture, a few are still wooded, and others are supplying sand and gravel. (Capability unit IIIw–5 (4b); woodland suitability group F)

Gladwin sandy loam, 2 to 6 percent slopes (GeB).—This soil occurs on outwash plains and on low terraces along streams on the uplands. Associated with it are Gilford and Lacota soils, which are in lower positions and are more poorly drained, and Mancelona and Montcalm soils, which are at higher elevations and are better drained.

Included with this soil in mapping were areas in the southeastern part of the county in which the reaction is more acid than is typical and the depth to the underlying material is more than 40 inches. Also in this part of the county are areas in which the surface layer is thicker than is typical and the upper part of the subsoil is yellowish brown. The subsoil is very strongly acid in places. In other areas limy clay loam occurs at a depth of 40 to 66 inches and the sandy and gravelly layer is thin and is less alkaline than is typical; most of these areas are where the plains and uplands merge. Included also were small areas in depressions and waterways in which the surface layer is thicker and darker colored than that in the typical profile; spots in which the dark-brown subsoil is exposed as a result of erosion; small areas that are nearly level; and some higher spots where the upper part of the subsoil is free of mottles.

Fertility is medium, and the available water capacity is low. Although the water table does not rise as close to the surface as in the nearly level soil of this series, drainage is needed for most crops. The soil becomes droughty when the water table recedes in summer. Soil blowing is a hazard, especially during the dry months of summer.

Most areas of this soil have been cleared and cultivated. Corn, small grain, and hay are the common crops. Some areas once cultivated are now idle or are used for pasture. A few areas are still wooded, and a few are supplying sand and gravel. (Capability unit IIIw–5 (4b); woodland suitability group F)

Glendora Series

The Glendora series consists of poorly drained to very poorly drained soils on first bottoms. These soils are underlain with coarse-textured material at a depth of only 10 inches.

In a typical profile, the surface layer consists of black sandy loam and is about 10 inches thick. Below this is about 15 inches of loamy sand; the upper 6 inches is grayish brown and mottled, and the lower 9 inches is pale brown and mottled. At a depth of 25 inches is grayish-brown, mottled, loose sand.

Fertility is low, the available water capacity is low, and permeability is rapid. Floods are frequent. Runoff is very slow, and water ponds after heavy rain and after floods.

Most areas are idle or in pasture or woods. The native vegetation consists mainly of low-quality, slow-growing lowland hardwoods, including elm, ash, and cottonwood; it also contains some northern white-cedar. Trees are shallow rooted.

Typical profile of Glendora sandy loam, undisturbed, located in the NW¼NE¼NW¼ sec. 13, T. 7 N., R. 16 W. (Grand Haven Township):

A1—0 to 10 inches, black (10YR 2/1) sandy loam; weak, medium, granular structure; friable; slightly acid; abrupt, wavy boundary.

C1g—10 to 16 inches, grayish-brown (10YR 5/2) loamy sand; common, medium, distinct, very dark gray (10YR 3/1) and few, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, medium, subangular blocky structure; very friable; neutral; clear, wavy boundary.

C2—16 to 25 inches, pale-brown (10YR 6/3) loamy sand; common, coarse, distinct, dark grayish-brown (10YR 4/2) mottles; weak, coarse, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

C3—25 to 50 inches, grayish-brown (10YR 5/2) sand; few, coarse, distinct, very dark gray (10YR 3/1) mottles; single grain; loose; mildly alkaline.

The reaction of the profile ranges from medium acid to mildly alkaline.

The color of the A1 horizon ranges to very dark grayish brown (10YR 3/1), and the texture to loamy sand. In a few places a thin layer of organic material covers the surface.

In the C horizon the basic color ranges from gray (10YR 5/1) to pale brown (10YR 6/3). Mottles in this horizon are faint to prominent. The C1g, C2, and C3 horizons vary in thickness as well as in texture and other characteristics. Thin strata of finer textured material occur in some profiles, and a thin layer of organic material or of dark-colored alluvium in some. The lower part of the C horizon is gravelly in places.

Glendora soils and Algansee soils formed in similar material. Glendora soils are in lower positions and are more poorly drained than Algansee soils. Glendora soils and Granby soils

have similar drainage, but Glendora soils formed in alluvial material and have a less coarse textured substratum than Granby soils.

Glendora sandy loam (0 to 2 percent slopes) (Gl).—This soil is on first bottoms, mainly in the western part of the county. It has short slopes, generally of less than 2 percent. Associated with it are areas of Algansee soils, which occupy second bottoms and natural levees.

In some places a thin layer of organic material covers the surface. Included in mapping were spots of Algansee soils.

Fertility is low, the available water capacity is low, permeability is rapid, and runoff is very slow to ponded. Floods are frequent. Frost is a hazard.

Most areas of this soil are in woods or pasture. Some are idle. (Capability unit IIIw–14 (L–4c); woodland suitability group O)

Granby Series

The Granby series consists of poorly drained and very poorly drained soils that occur both on plains and on uplands.

In a typical profile, the surface layer consists of black loamy sand and is about 10 inches thick. Below the surface layer, and extending to a depth of at least 60 inches, are layers of dark-gray, light brownish-gray, and light-gray, mottled, loose or very friable sand.

Fertility is low, the available water capacity is low, permeability is rapid, and runoff is very slow to ponded. Controlled artificial drainage is needed for most crops; droughtiness results if the water table is lowered too much. Soil blowing is a hazard when the soil is dry and exposed.

Most areas of these soils have been cleared and cultivated. Many are now idle or used for pasture. Almost all areas now cultivated are drained artificially, mainly by means of open ditches. Some areas are still wooded. The native vegetation consists mainly of lowland hardwoods, including elm, ash, red maple, cottonwood, and some willow; it also contains some spruce and northern white-cedar.

Typical profile of Granby loamy sand, cultivated, located in the SE¼SE¼NE¼ sec. 28, T. 7 N., R. 15 W. (Robinson Township):

Ap—0 to 10 inches, black (10YR 2/1) loamy sand; high in organic-matter content; weak, medium, granular structure; very friable; neutral; abrupt, wavy boundary.

C1g—10 to 16 inches, dark-gray (10YR 4/1) sand; weak, coarse, subangular blocky structure; loose; slightly acid; gradual, wavy boundary.

C2—16 to 32 inches, light brownish-gray (10YR 6/2) sand; common, medium, distinct, dark-gray (10YR 4/1) and gray (10YR 5/1) mottles; weak, coarse, subangular blocky structure; very friable; neutral; clear, wavy boundary.

C3—32 to 60 inches, light-gray (10YR 7/2) sand; common, medium, faint, grayish-brown (10YR 5/2) mottles and few, medium, distinct, gray (10YR 5/1) mottles; single grain; loose; neutral.

In some places a layer of muck less than 12 inches thick is at the surface.

The texture of the Ap horizon is loam, fine sandy loam, sandy loam, loamy sand, or loamy fine sand. The color of this horizon ranges to very dark gray (10YR 3/1). Where the Ap horizon is less than 10 inches thick, it is underlain with a black (10YR 2/1) or very dark gray (10YR 3/1) A1 horizon that is 2 to 6 inches thick. The thickness of the Ap horizon, or of the Ap and the A1 together, is 10 to about 15 inches. In some places the profile includes a gray (10YR 6/1 or 5/1) A2g horizon 4 to 8 inches thick.

The texture of the C1g horizon is loamy sand in some places. Faint to prominent mottles occur in this horizon in some profiles. In a few places there are thin, discontinous layers of very fine sand, silt, and loam below a depth of 20 inches.

The reaction in the Ap horizon and the upper part of the C horizon ranges from medium acid to neutral.

Granby soils occur near Adrian, Gilford, and Glendora soils. They differ from Adrian soils in consisting mainly of mineral rather than organic material; they lack the B2 horizon and the sandy and gravelly IICg horizon that is characteristic of Gilford soils; and they formed from a different kind of material than Glendora soils and are not subject to flooding.

Granby loamy sand (0 to 2 percent slopes) (Gm).—This soil is on plains and in wet depressions on uplands. Most areas of it are in the western part of the county. The individual areas are fairly large. Associated with this soil are Granby fine sandy loam and Au Gres-Saugatuck sands, 0 to 6 percent slopes.

This soil has the profile described as typical of the series. There are areas in which the surface layer is darker colored and is less than 10 inches thick. In some such areas the reaction throughout the profile is more acid than is typical. Loamy sand is the dominant texture in some profiles. In areas that have been cultivated for a long time, the surface layer is lighter colored, and in some cultivated areas the dark-colored surface layer has been completely removed by erosion. A salt-and-pepper appearance of the surface in some areas is the result of soil blowing, which has mixed dark-colored sand or loamy sand from the surface layer with lighter colored sand from lower layers. In some depressions where the soil is undisturbed, a layer of organic material as much as 12 inches thick is at the surface. Included in mapping were spots of Adrian soils; small areas of Au Gres-Saugatuck sands, 0 to 6 percent slopes, on slight knolls and ridges; areas of Brevort and Pinconning soils, which are of loamy texture within 42 inches of the surface and occur where the sandy plains and loamy uplands meet; gently sloping areas near the margins of depressions; better drained soils at slightly higher elevations; and spots of soils that are dominantly of sandy loam texture below the surface layer.

Fertility is low, and the available water capacity is low. The water table is high. Soil blowing and loss of organic matter are likely if the water table is lowered by artificial drainage. Frost damage to crops is a hazard.

Many areas of these soils have been cleared and drained and are cultivated. Long rotations that consist largely of close-growing and early-maturing crops are usual. Specialty crops, including blueberries, melons, and pickling cucumbers, are grown in selected areas. Many areas are idle, and others are used only for pasture. (Capability unit IIIw–11 (5c); woodland suitability group Q)

Granby fine sandy loam (0 to 2 percent slopes) (Gn).—This soil is on plains and in wet depressions on uplands. Most areas are in the western part of the county. The individual areas are fairly large. Associated with this soil are Granby loamy sand and Au Gres-Saugatuck sands, 0 to 6 percent slopes.

The surface layer is very dark gray or black. The lower layers contain more fine sand than is typical of the series. In some areas the surface layer is less than 10 inches thick; in other areas the reaction in the upper part of the

profile is more acid than is typical. Loamy sand is the dominant texture in some places, especially in the smaller depressions. Where the soil has been cultivated for a long time, the surface layer is lighter colored; in some cultivated areas the dark-colored surface layer has been completely removed by erosion. A salt-and-pepper appearance of the surface in some areas is the result of soil blowing, which has mixed dark-colored sand or loamy sand from the surface layer with lighter colored sand from lower layers. In some depressions where the soil is undisturbed, a layer of organic material as much as 12 inches thick is at the surface. Spots of Adrian soils were included in mapping. Also included were gently sloping areas near the margins of depressions.

Fertility is low. The available water capacity is slightly higher than that of Granby loamy sand. The water table is high. Soil blowing and loss of organic matter are likely if the water table is lowered by artificial drainage.

Many areas have been drained and are used for crops. Long rotations in which close-growing and early-maturing crops predominate are usual. Many areas are idle or are used only for native pasture. (Capability unit IIIw–11 (5c); woodland suitability group Q)

Gravel Pits

A number of Gravel pits (Gr) in Ottawa County are large enough to be shown on the soil map as separate units. Those too small to be delineated separately are shown by symbols. Also shown as part of this mapping unit are borrow pits, which are areas from which material other than gravel has been removed for use at another location. Some relatively new gravel pits, mostly in the western part of the county, are not shown on the soil map.

Along the Grand River are some very large pits from which large amounts of gravel are being removed. The gravel is transported by barge to Lake Michigan and from there to markets outside the county. A number of older pits have been abandoned; some of these are now covered with scattered trees, brush, and weeds; some are bare of vegetation; and some are filled with water but are unsafe for recreational uses. The abandoned pits are used by wildlife. (Capability unit VIIIs–1 (Sa); no woodland suitability classification)

Hettinger Series

The Hettinger series consists of poorly drained soils that occur on water-worked till plains, on lake plains, and in glacial drainageways. These soils developed in stratified silty clay loam, clay loam, and silt loam.

In a typical profile, the surface layer consists of black loam and is about 8 inches thick. The subsoil is about 20 inches thick. The uppermost 3 inches is mottled light-gray and dark-gray, friable to firm heavy silt loam; the next 9 inches is mottled grayish-brown and very dark gray, firm silty clay loam; and the lowermost 8 inches is mottled light-gray and dark-gray, friable light silty clay loam. The underlying material, at a depth of 28 inches, consists of a 4-inch layer of grayish-brown, mottled, limy silty clay loam over light brownish-gray, mottled, limy, silty clay loam stratified with a few thin layers of very dark gray silt loam.

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Fertility is high, the available water capacity is high, permeability is moderately slow, and runoff is slow to ponded. The water table is high much of the year unless lowered by artificial drainage. The excessive wetness hinders plant growth and interferes with the use of machinery. The soils warm up slowly in spring. Frost damage to crops is a hazard.

If artificially drained, Hettinger soils are well suited to crops, and most areas have been cleared and are cultivated. Installation and maintenance of drainage facilities are difficult in places. A few areas are still wooded. The native vegetation is a mixture of lowland hardwoods, including elm, red maple, ash, swamp white oak, and some sycamore.

Typical profile of Hettinger loam, cultivated, located in the NW¼NE¼NE¼ sec. 34, T. 6 N., R. 15 W. (Olive Township):

Ap—0 to 8 inches, black (10YR 2/1) loam; moderate, medium, granular structure; friable; neutral; abrupt, wavy boundary.

B1g—8 to 11 inches, mottled light-gray (10YR 6/1) and dark-gray (10YR 4/1) heavy silt loam; vertical streaks of very dark gray (10YR 3/1); weak, medium, subangular blocky structure; friable to firm; neutral; clear, wavy boundary.

B21g—11 to 20 inches, mottled grayish-brown (2.5Y 5/2) and very dark gray (N 3/0) silty clay loam; weak, coarse, subangular blocky structure; firm; mildly alkaline; clear, wavy boundary.

B22g—20 to 28 inches, mottled light-gray (10YR 6/1) and dark-gray (10YR 4/1) light silty clay loam; weak, coarse, angular blocky structure; friable; calcareous; clear, wavy boundary.

C1g—28 to 32 inches, grayish-brown (10YR 5/2) silty clay loam; many, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, medium, angular blocky structure; firm; calcareous; abrupt, wavy boundary.

C2g—32 to 50 inches, light brownish-gray (2.5Y 6/2), stratified silty clay loam; many, medium, faint, light-gray (2.5Y 7/2) mottles and few, fine, distinct, very dark gray (N 3/0) mottles; weak, medium, angular blocky structure; firm; thin strata of very dark gray (N 3/0) silt loam.

The reaction of the solum ranges from slightly acid to moderately alkaline. Some profiles are calcareous at a depth of 12 inches.

In undisturbed areas there is a black (10YR 2/1) or very dark gray (10YR 3/1) A1 horizon that is 6 to 10 inches thick.

The color of the Ap horizon ranges to very dark brown (10YR 2/2), and the texture is clay loam, silt loam, loam, or sandy loam. Below the Ap horizon in some places is an A1 horizon that is 1 to 3 inches thick and has a clear or abrupt lower boundary.

In the Bg horizon, the colors have a hue of 10YR or 2.5Y, a value of 4, 5, or 6, and a chroma of 1 or 2. The mottles in this horizon are faint to prominent. The texture is dominantly silty clay loam or clay loam, but in some places this horizon includes 1- to 6-inch strata of silt loam, loam, or fine sandy loam.

The texture of the Cg horizon also is dominantly silty clay loam or clay loam, but in some places this horizon includes 1- to 6-inch strata of clay, very fine sandy loam, silt loam, loam, or sand.

Hettinger soils are in the same drainage class as Sims and Bruce soils and occupy similar positions on the landscape. Hettinger soils have thin layers of silt loam in the C2g horizon, which Sims soils lack. They have a finer textured Cg horizon than Bruce soils.

Hettinger loam (0 to 2 percent slopes) (Hg).—This nearly level to depressional soil occurs on water-worked till plains, on lake plains, and in glacial drainageways.

In some areas the texture of the surface layer is clay loam, silt loam, or sandy loam. In the old glacial drainageway in Tallmadge Township, the surface layer is thicker

than is typical, one or more layers of fine-textured alluvium occur at a depth of 2 to 3 feet, and coarse-textured material occurs below a depth of 3 feet. Included in mapping were spots of Bowers soils, which are less poorly drained than Hettinger soils; spots of Bruce soils, which are slightly coarser textured throughout; and spots of Sims soils, which lack the strata of silt loam in the underlying material.

Fertility is high, and the available water capacity is high. Frost damage to crops is a hazard in some places. Artificial drainage is needed.

If drained this soil is well suited to crops. Most areas have been cleared and are cultivated. Corn, small grain, and hay are the common crops. Cropping systems are commonly 3 to 4 years long. A few areas are still wooded, but trees grow slowly and are of low quality. (Capability unit IIw–2 (1.5c); woodland suitability group P)

Hillsdale Series

The Hillsdale series consists of well-drained soils that occur in the undulating to rolling countryside in the southeastern part of the county.

In a typical profile, the surface layer consists of dark grayish-brown sandy loam and is only 3 inches thick. Below this is a 4-inch subsurface layer of pale-brown, friable sandy loam. The subsoil extends to a depth of 78 inches. It consists of 7 inches of yellowish-brown over dark yellowish-brown, friable sandy loam; 9 inches of dark-brown, friable sandy clay loam; and 55 inches of strong-brown, friable sandy loam. The underlying material is light yellowish-brown sandy loam.

Fertility is medium, the available water capacity is moderate, and permeability is moderate. Runoff is moderate to rapid, depending on the slope. In dry years, most crops are affected by a moisture shortage late in the growing season. Erosion and soil blowing are hazards.

Most areas of Hillsdale soils have been cleared and are used for crops. A few areas are in orchards, a few are in pasture, and a few are still wooded. The native vegetation is a mixture of hardwoods, including sugar maple, oak, and hickory.

Typical profile of Hillsdale sandy loam, 2 to 6 percent slopes, undisturbed, located in the NE¼NE¼NE¼ sec. 36, T. 5 N., R. 13 W. (Jamestown Township):

A1—0 to 3 inches, dark grayish-brown (10YR 4/2) sandy loam; moderate, medium, granular structure; friable; strongly acid; abrupt, smooth boundary.

A2—3 to 7 inches, pale-brown (10YR 6/3) sandy loam; weak, thin, platy structure; friable; very strongly acid; gradual, wavy boundary.

B1—7 to 11 inches, yellowish-brown (10YR 5/4) sandy loam; moderate, medium, subangular blocky structure; friable; very strongly acid; clear, wavy boundary.

B21t—11 to 14 inches, dark yellowish-brown (10YR 4/4) heavy sandy loam; moderate, medium, subangular blocky structure; friable; extremely acid; clear, wavy boundary.

B22t—14 to 23 inches, dark-brown (7.5YR 4/4) sandy clay loam; strong, coarse, subangular blocky structure; friable; extremely acid; clear, wavy boundary.

B23—23 to 43 inches, strong-brown (7.5YR 5/6) sandy loam; moderate, medium, subangular blocky structure; friable; extremely acid; gradual, wavy boundary.

B3—43 to 78 inches, strong-brown (7.5YR 5/6) sandy loam; weak, medium, subangular blocky structure; friable; very strongly acid in upper part, grading to strongly acid in lower part; gradual, wavy boundary.

C—78 inches +, light yellowish-brown (10YR 6/4) sandy loam; weak, coarse, subangular blocky structure; friable; medium acid.

The solum is 3½ to more than 6 feet thick. In reaction it is extremely acid or strongly acid.

In cultivated areas the A1 and A2 horizons have been mixed and now form an Ap horizon that is 6 to 10 inches thick. The texture of the Ap horizon is loam, fine sandy loam, sandy loam, or loamy sand, and the color is dark gray (10YR 4/1) or dark grayish brown (10YR 4/2).

The texture of the A1 horizon is loam, fine sandy loam, sandy loam, or loamy sand. In the A2 horizon the color ranges to brown (10YR 5/3).

The color of the B1 horizon ranges to dark brown (10YR 4/3). Some profiles lack a B1 horizon. In the B2 and B3 horizons, the colors have a hue of 7.5YR or 10YR, a value of 4 or 5, and a chroma of 3, 4, or 6. The texture of the B2 horizon ranges from sandy loam to sandy clay loam or light clay loam. The weighted average clay content of the B2 horizon is less than 18 percent. In places the solum contains pockets or discontinuous layers of loamy sand and sand 2 to 12 inches thick; generally these are below a depth of 36 inches.

The C horizon has a loamy sand texture in places. It contains pockets of noncalcareous sand and gravel. In reaction it ranges from strongly acid to moderately alkaline, commonly being strongly acid in the uppermost few inches and becoming less acid with increasing depth.

Hillsdale soils occur near Miami, Spinks, and Oshtemo soils. Hillsdale soils have a coarser textured and more acid C horizon than Miami soils; they have a thicker and finer textured Bt horizon than Spinks soils; and they lack the sandy and gravelly IIC horizon that is characteristic of Oshtemo soils.

Hillsdale sandy loam, 2 to 6 percent slopes (HlB).—Most of this soil is on hillsides and rounded hilltops in the southeastern part of the county.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. In some areas the plow layer consists of dark grayish-brown sandy loam and the subsurface layer is lacking or very thin. Included in mapping were spots that have a coarser textured layer and subsoil, small spots in which the surface layer is loam, some in which the reaction is less acid than is typical, and a few short slopes of more than 6 percent. In an area located partly in Jamestown Township and partly in Zeeland Township, the profile contains more fine sand than is typical, the slope range is 0 to about 4 percent, drainage is moderately good, and the reaction is less acid than is typical.

Fertility is medium, and the available water capacity is moderate. The organic-matter content is low. In prolonged periods of dry weather, the soil becomes droughty. It is easily eroded and is susceptible to blowing. Where eroded it becomes hard and crusty upon drying.

Nearly all areas have been cleared and are cultivated. Corn, small grain, and hay are the common crops. Orchards occupy some of the higher sites. There are a few second-growth woodlots. (Capability unit IIe–3 (3a); woodland suitability group K)

Hillsdale sandy loam, 6 to 12 percent slopes (HlC).—This soil occurs mainly on hillsides in rolling areas in the southeastern part of the county.

In most areas there is a plow layer of dark grayish-brown sandy loam and no subsurface layer. The depth to the light yellowish-brown underlying material is less than in the typical profile. In some eroded areas the surface layer is dark yellowish-brown sandy loam, the subsurface layer is dark-brown sandy clay loam, and the depth to the underlying material is about 42 inches. Included in map-

ping were short, irregular slopes of more than 12 percent and some slopes of less than 6 percent.

Fertility is medium, and the available water capacity is moderate. Runoff is rapid. In eroded areas the organic-matter content is very low, tilth is poor, and the surface is hard and crusty when dry. Erosion is a serious hazard. The moisture supply is deficient late in the growing season.

Most areas have been cleared and are cultivated. Corn, small grain, and hay are the common crops. Long cropping systems that include more than 2 years of hay are usual. A few areas are now in orchard, some are in grass, and a few are still wooded. (Capability unit IIIe-5 (3a); woodland suitability group K)

Houghton Series

The Houghton series consists of poorly drained, nearly level to depressional, organic soils that occur on wet plains, in drainageways, and on flood plains in the western part of the county. These soils consist of organic material derived mainly from reeds, sedges, and other herbaceous plants. In Ottawa County, Houghton soils occur in intricate patterns with Adrian soils and were mapped only as part of the complex called Adrian-Houghton mucks.

In a typical profile of a Houghton soil, the surface layer consists of a well-decomposed, fibrous, black muck and is about 12 inches thick. Below this is a 6-inch layer of partly decomposed, woody and fibrous, black mucky peat. Below a depth of 18 inches is fibrous peat; the uppermost 7 inches of this is very dark brown, the next 7 inches is very dark grayish brown, and the part below a depth of 32 inches is dark reddish brown. The peat extends to a depth of several feet.

Fertility is low, the available water capacity is high, and runoff is very slow to ponded. The water table is high unless lowered by artificial drainage. Permeability is rapid if the water table is lowered. The organic material is likely to settle if overdrained. Frost damage to crops is a hazard. When dry, the soils are susceptible to blowing.

Many areas are used for crops. Corn is grown in some of these areas, and special crops, including celery, onions, carrots, and mint, in others. Some areas are in pasture. The native vegetation is made up largely of fibrous plants, including marsh grasses, sedges, reeds, and cattails; it also includes herbs and lowland trees.

Typical profile of Houghton muck, undisturbed, located in the NW¼NE¼SW¼ sec. 35, T. 8 N., R. 15 W. (Crockery Township):

1—0 to 12 inches, black (10YR 2/1), well-decomposed, fibrous muck; weak, medium, granular structure; friable; neutral; clear, smooth boundary.

2—12 to 18 inches, black (5YR 2/1) partly decomposed, mixed woody and fibrous mucky peat; weak, medium, subangular blocky structure; friable; neutral; diffuse, smooth boundary.

3—18 to 25 inches, very dark brown (10YR 2/2), finely divided, fibrous peat; massive, friable; this horizon has a pasty appearance; slightly acid; clear, smooth boundary.

4—25 to 32 inches, very dark grayish-brown (10YR 3/2), finely divided, fibrous peat; massive; friable; neutral; clear, smooth boundary.

5—32 to 60 inches, dark reddish-brown (5YR 2/2), fine, fibrous peat; massive; friable; neutral.

The reaction of the profile ranges from neutral to medium acid.

The color of the surface layer is very dark brown (10YR 2/2) in places. The second layer contains a few woody fragments. In some profiles the color of the fibrous peat becomes more yellow with increasing depth. In places mineral soil material underlies the organic material at a depth of 42 to 66 inches.

Houghton soils are similar to Carlisle, Adrian, and Linwood soils. Houghton soils consist of material derived from herbaceous plants, and Carlisle soils of material derived from woody plants. Houghton soils typically consist of organic material to a depth of at least 5 feet; Adrian soils have a sandy IIC horizon and Linwood soils a loamy IIC horizon within 42 inches of the surface.

Iosco Series

The Iosco series consists of somewhat poorly drained soils that occur on lake plains and till plains. These soils developed in 18 to 40 inches of sandy material over clay loam and silty clay loam.

In a typical profile, the surface layer consists of dark grayish-brown loamy sand and is about 8 inches thick. Below this is a 4-inch subsurface layer of light-gray sand. The B horizon is about 22 inches thick. The uppermost 5 inches is very dusky red and dark reddish-brown, very friable sand; the next 14 inches is yellowish-brown over light yellowish-brown, mottled, loose sand; and the lowermost 3 inches is brown, mottled, firm light silty clay loam. The underlying material, at a depth of 34 inches, is gray, mottled, limy clay loam.

Fertility is low, the available water capacity is low, and runoff is slow. Permeability is rapid in the upper part of the profile and moderately slow in the lower part. The water table rises to within a foot or two of the surface during prolonged periods of wet weather. Unless it is lowered by artificial drainage, it delays tillage and planting and restricts root development.

Iosco soils are fairly well suited to crops, and most areas have been cleared and are cultivated. Some areas are still wooded. The native vegetation consists largely of hardwoods, including aspen, maple, oak, and elm; it also contains some white pine.

Typical profile of Iosco loamy sand, 0 to 4 percent slopes, cultivated, located in the SE¼NW¼NW¼ sec. 19, T. 8 N., R. 13 W. (Wright Township):

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; abrupt, smooth boundary.

A2—8 to 12 inches, light-gray (10YR 6/1) sand; weak, medium, subangular blocky structure breaking to single grain; loose; medium acid; clear, irregular boundary.

B21hir—12 to 17 inches, very dusky red (2.5YR 2/2) and dark reddish-brown (2.5YR 3/4) sand; weak, medium and coarse, subangular blocky structure; very friable; high in organic-matter content; medium acid; clear, wavy boundary.

B22ir—17 to 25 inches, yellowish-brown (10YR 5/8) sand; many, medium, faint, light yellowish-brown (10YR 6/4) mottles; weak, medium, subangular blocky structure breaking to single grain; loose; medium acid; clear, wavy boundary.

B3—25 to 31 inches, light yellowish-brown (10YR 6/4) sand; many, medium, distinct, yellowish-brown (10YR 5/8) mottles; single grain; loose; slightly acid; clear, wavy boundary.

IIB't—31 to 34 inches, brown (10YR 5/3) light silty clay loam; common, medium, faint, grayish-brown (10YR 5/2) mottles and many, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive; firm; mildly alkaline; clear, wavy boundary.

IICg—34 to 60 inches, gray (10YR 5/1) clay loam; many, medium, distinct, yellowish-brown (10YR 5/6) mottles and common, medium, faint, grayish-brown (10YR 5/2) mottles; moderate, medium, subangular blocky structure; firm; calcareous.

The depth to the IIB't horizon ranges from 18 to 40 inches. The reaction in this horizon ranges from mildly alkaline to medium acid, and the reaction of the solum above this horizon from slightly acid to strongly acid. In some places the solum contains gravelly material.

In undisturbed areas there is a very dark gray (10YR 3/1) A1 horizon.

The texture of the Ap horizon is sand in places, and the color ranges to very dark grayish brown (10YR 3/2). In the A2 horizon the color ranges to pinkish gray (7.5YR 6/2–7/2) or light gray (10YR 7/1). Where the Ap horizon is more than 8 inches thick, there may be no A2 horizon. The color of the B21hir horizon ranges to dark reddish brown (5YR 3/2 or 2.5YR 3/4), and that of the B22ir to dark brown (7.5YR 4/4) or dark yellowish brown (10YR 4/4). The texture of both the B21hir and the B22ir horizons is loamy sand in places. Chunks of ortstein occur in these horizons in some places.

An A'2 horizon occurs just above the IIB't horizon in some profiles. The color of the A'2 horizon is grayish brown (10YR 5/2), brown (10YR 5/3), or pale brown (10YR 6/3).

In the IIB't horizon, the color ranges to yellowish brown (10YR 5/6), and the texture is sandy clay, sandy clay loam, or silty clay loam.

The texture of the IICg horizon is clay loam or silty clay loam.

Iosco soils and Menominee soils formed in similar material. Iosco soils are less well drained than Menominee soils and have more mottles in the upper part of the profile. Iosco soils are in the same drainage class as Allendale and Belding soils. They have a coarser textured IICg horizon than Allendale soils and a coarser textured B22ir horizon than Belding soils.

Iosco loamy sand, 0 to 4 percent slopes (IoA).—This soil is on lake plains and till plains. It occupies low sandy ridges and long slopes next to drainageways. Nearly all areas are in the eastern part of the county. The individual areas are not large. Associated with this soil are Belding, Breckenridge, Kawkawlin, Nester, and Sims soils.

This Iosco soil has the profile described as typical of the series, but variations in the profile occur from place to place. In some places the texture of the surface layer is sandy loam or sand, and in some the texture is sandy loam throughout the surface layer and subsoil. In other places the subsoil includes a cemented sand layer, and in still others it contains some gravel. Some areas have an irregular surface. Included in mapping were areas of Brevort and Breckenridge soils, which are in minor depressions and drainageways; of Au Gres soils, in which sandy material extends to a depth of more than 40 inches; of Kawkawlin soils, in which clay loam occurs at a depth of less than 18 inches; and of Belding soils, which are slightly finer textured than Iosco soils in the upper part of the profile. Also included are some areas in which the slope is more than 4 percent.

Fertility is low. Artificial drainage is needed to remove excess water in spring and in wet weather at other times of the year, but the available water capacity is low and during prolonged periods of dry weather the soil dries out and crops show the effects of moisture deficiency.

Most of this soil is used for crops; some is used for pasture, and some is still wooded. Most areas are within fields that include other soils, and the irregular surface and sandy texture of this Iosco soil result in uneven growth of crops in such fields. (Capability unit IIIw–9 (4/2b); woodland suitability group G)

Iosco and Allendale loamy sands, 0 to 4 percent slopes (IrA).—This mapping unit is in the western part of the county; it occurs on lake plains, on uplands, and in the areas where the plains and uplands merge. Some areas consist predominantly of Iosco loamy sand and some predominantly of Allendale loamy sand. The two soils differ mainly in the texture of the underlying material. Iosco soils are underlain with clay loam or silty clay loam at a depth of less than 40 inches, and Allendale soils have silty clay or clay at a depth of less than 40 inches.

Iosco loamy sand predominates in small areas on lower slopes and in pockets on the uplands; the surface in these areas is irregular. Larger areas that are mostly Iosco loamy sand occur where the uplands and plains merge; in these areas the slope is more uniform. In places the texture of the Iosco soil is loamy fine sand. Included in mapping were eroded spots, some on knolls and ridges, in which the surface layer is sand and is lighter colored than that of the uneroded soil. Also included were spots of Brevort and Breckenridge soils in minor depressions, and spots of Au Gres soils, which are sandy to a depth of more than 40 inches.

Allendale loamy sand predominates in the areas on lake plains. The larger of these areas are on gradual slopes to drainageways; in these places a sandy smear overlies the silty clay material. The smaller areas are on low, narrow ridges; in these the texture is finer than is typical. The texture of the Allendale soil is sandy loam or sand in some places. Included in mapping were spots of darker colored Pinconning and Hettinger soils in minor drainageways and small depressions.

These Iosco and Allendale soils have a fluctuating water table that is high in spring and in the early part of summer. Artificial drainage is needed for most crops, but during the summer the water table recedes and crops show the effects of moisture deficiency. Both water erosion and soil blowing are hazards.

Nearly all areas of this unit have been cleared and cultivated. Corn, small grain, and hay are the common crops. Some areas are idle, and some are used for pasture. A few are wooded; most of these have been planted to pines intended for Christmas trees. (Capability unit IIIw-9 (Iosco—4/2b, Allendale—4/1b); woodland suitability group G)

Iosco-Belding complex, 2 to 6 percent slopes (IsB).—In the western part of the county, Iosco loamy sand and Belding sandy loam occur together in such intricate patterns that neither can be shown separately on the soil map. The larger areas of this complex are on the lower part of slopes on uplands; the smaller are on low ridges on lake plains. The main difference between the two soils is that Iosco soils developed in sandy material and Belding soils in sandy loam material. Most areas are about 65 percent Iosco loamy sand, about 25 percent Belding sandy loam, and 10 percent other soils.

In some parts of this complex, the surface layer is sandy loam and the subsoil is sandy material; in other parts, the surface layer is loamy sand and the subsoil sandy loam. Included in mapping were spots of Menominee and Ubly soils that have slopes of more than 6 percent; of darker colored, more poorly drained Brevort and Breckenridge soils, which are in small depressions and waterways; and of eroded soils in which the surface layer is lighter colored

and the underlying material is within 18 inches of the surface.

These soils have a fluctuating water table that is only a foot or two below the surface during prolonged periods of wet weather but is lower during the dry months of summer. Artificial drainage is needed for most crops. Both water erosion and soil blowing are hazards.

Nearly all of this complex has been cleared and cultivated. Some is now idle, some is used for hay or pasture, and some has been planted to pine intended for Christmas trees. A few areas have never been cleared. Corn, small grain, and hay are the common crops. Cropping systems commonly consist mainly of small grain and hay. (Capability unit IIIw–9 (Iosco—4/2b, Belding—3/2b); woodland suitability group G)

Kalkaska Series

The Kalkaska series consists of well-drained soils that occupy long, narrow ridges and interior dunes in the western part of the county. These soils developed in deposits of acid sand.

In a typical profile, the surface layer consists of very dark gray sand and is only about 3 inches thick. Below it is a 4-inch subsurface layer of light-gray sand. The subsoil, about 23 inches thick, consists of very friable sand; it is dark reddish brown in the uppermost 6 inches, dark brown in the next 8 inches, and strong brown in the lowermost 9 inches. The underlying material, at a depth of about 30 inches, is light yellowish-brown sand.

Fertility is low, the available water capacity is low, permeability is rapid, and runoff is slow.

There are a few active blowouts, but most areas of this soil are covered with second-growth trees or beachgrass. Some areas were first stabilized with beachgrass and then planted with pine. The native vegetation is a mixture of conifers and hardwoods, including white pine, oak, and aspen. Some areas are now covered with sassafras, fire cherry, sweetgum, and sumac.

Typical profile of Kalkaska sand, undisturbed, located in the NW¼SE¼NE¼ sec. 13, T. 6 N., R. 16 W. (Port Sheldon Township):

A1—0 to 3 inches, very dark gray (10YR 3/1) sand; weak, medium, granular structure; very friable; slightly acid; abrupt, smooth boundary.

A2—3 to 7 inches, light-gray (10YR 6/1) sand; weak, coarse, subangular blocky structure; loose; medium acid; abrupt, wavy boundary.

B21hir—7 to 13 inches, dark reddish-brown (5YR 3/4) sand; weak, coarse, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

B22ir—13 to 21 inches, dark-brown (7.5YR 4/4) sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B23ir—21 to 30 inches, strong-brown (7.5YR 5/6) sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, irregular boundary.

C—30 to 66 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; slightly acid.

The solum is 20 to about 36 inches thick. In reaction it ranges from very strongly acid to slightly acid.

In some places a thin mat of black organic material is at the surface.

The color of the A1 horizon ranges to black (N 2/0) or very dark gray (N 3/0), and that of the A2 to gray (10YR 5/1) or pinkish gray (7.5YR 6/2–7/2). In cultivated areas there is an Ap horizon that is 6 to 10 inches thick and is very dark grayish brown (10YR 3/2), dark grayish brown (10YR 4/2), or very dark brown (10YR 2/2) in color.

In the B21hir horizon the color has a hue of 2.5YR, 5YR, or 7.5YR, a value of 2 or 3, and a chroma of 4 or less. In some places this horizon contains chunks of ortstein. In the B22ir horizon the hue is 5YR or 7.5YR and both the value and the chroma are 4 or less.

The color of the C horizon ranges to brown (10YR 5/3) or pale brown (10YR 6/3). In places this horizon is faintly mottled. Thin, discontinuous color bands occur below a depth of 48 inches in some profiles.

Kalkaska soils formed in material similar to that in which Rubicon and Croswell soils formed. They have a dark reddish-brown B21hir horizon, which Rubicon soils lack. They are better drained than Croswell soils and are unmottled.

Kalkaska sand, 0 to 12 percent slopes (KaC).—This soil occupies long, narrow ridges and interior dunes on outwash plains and lake plains. Nearly all areas are in the western part of the county.

Some of the ridges are low and are within plains where Au Gres and Saugatuck soils are dominant. In such places drainage is poorer than is typical, the lower part of the subsoil is mottled, and in some spots the profile includes a cemented subsoil. Included in mapping were spots of Rubicon soils, which lack the dark reddish-brown layer in the subsoil. Also included were severely eroded spots in which the light yellowish-brown underlying material is at the surface; less eroded spots in which the subsoil is at the surface; spots that have chunks of dark reddish-brown ortstein in the subsoil; and a few areas that have slopes of more than 12 percent.

Fertility is low, the available water capacity is low, runoff is slow, and permeability is rapid. The soil is susceptible to blowing and is difficult to stabilize after it has once started to blow.

This soil is not well suited to farming, but it does have value as forest, as a recreation area, and as wildlife habitat. (Capability unit IVs–4 (5a); woodland suitability group H)

Kawkawlin Series

The Kawkawlin series consists of somewhat poorly drained soils that occur on uplands and till plains. These soils developed in glacial till of clay loam or silty clay loam texture.

In a typical profile, the surface layer consists of dark-gray loam and is about 7 inches thick. The upper 7 inches of the subsoil consists of mottled, light-gray, friable loam and mottled, grayish-brown, firm clay loam; the lower 10 inches consists of reddish-brown, very firm heavy clay loam. The underlying material, at a depth of 24 inches, is gray, mottled, limy clay loam.

Fertility is high, the available water capacity is high, runoff is slow, and permeability is moderate. The organic-matter content is medium. Excessive wetness in spring and after rain in other seasons delays planting and tillage, interferes with the use of farm machinery, and restricts the development of roots. Drainage is needed for most crops.

Most areas of these soils have been cleared and are cultivated. Some small areas are wooded. The native vegetation consists mostly of hardwoods, among them maple, beech, oak, aspen, and birch; it also includes some white pine and hemlock.

Typical profile of Kawkawlin loam, 2 to 6 percent slopes,

cultivated and eroded, located in the NW¼NW¼NE¼ sec. 35, T. 6 N., R. 15 W. (Olive Township):

Ap—0 to 7 inches, dark-gray (10YR 4/1) loam; moderate, coarse, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

B&A—7 to 14 inches, light-gray (10YR 6/1), friable loam (A part) and grayish-brown (10YR 5/2), firm clay loam (B part); both parts have few, coarse, faint, gray (10YR 5/1) mottles and few, medium, distinct, light yellowish-brown (10YR 6/4) mottles; the B part has moderate, coarse, subangular blocky structure; the A part has weak, fine, granular structure; A material completely or partly surrounds peds and fills cracks, voids, and channels; neutral; clear, irregular boundary.

B2t—14 to 24 inches, reddish-brown (5YR 4/4) heavy clay loam; many, medium, distinct, gray (N 5/0) mottles; moderate, medium, subangular blocky structure; very firm; neutral; clear, wavy boundary.

Cg—24 to 50 inches, gray (10YR 6/1) clay loam; common, coarse, distinct, yellowish-brown (10YR 5/4) mottles and few, medium, faint, light-gray (10YR 7/1) mottles; strong, medium, subangular blocky structure; firm; calcareous.

The solum is 24 to about 40 inches thick. In the western part of the county, it is dominantly between 24 and 30 inches thick, and in the eastern part dominantly between 30 and 40 inches. The reaction of the solum is dominantly medium acid to neutral, but in some profiles the B2 horizon is mildly alkaline.

In undisturbed areas the profile has an A1 and an A2 horizon instead of an Ap horizon. The A1 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) and is 2 to 5 inches thick. The A2 horizon is grayish brown (10YR 5/2) or gray (10YR 6/1) and is as much as 7 inches thick. A2 material occurs as thick coatings around peds and in cracks and root channels in the upper part of the Bt horizon.

In the B2t horizon and in the B part of the A&B horizon, the color has a hue of 5YR, 7.5YR, or 10YR, a value of 4 or 5, and a chroma of 2, 3, or 4. The mottles generally have a chroma of 2 or less. The texture of the B horizon is dominantly clay or silty clay, but light clay occurs in the B2t horizon in some places. The weighted average clay content ranges from 35 to about 45 percent.

The texture of the C horizon is clay loam or silty clay loam.

Kawkawlin soils are in the same drainage class as Blount, Bowers, and Conover soils and occur in similar positions on the landscape. Kawkawlin soils differ from Blount and Conover soils in having a B&A horizon, and from Bowers soils in lacking stratification in the C horizon.

Kawkawlin loam, 0 to 2 percent slopes (KnA).—This soil is on till plains and in upland depressions. Associated with it are well-drained Nester soils, which are at higher elevations, and poorly drained Sims soils, which are in depressions.

In undisturbed areas the surface layer of this soil is very dark gray or very dark grayish brown. In most cultivated areas it is dark grayish brown. In some places the texture of the surface layer is silt loam, and in some it is sandy loam. Included in mapping were spots of Belding soils, in which the depth to clay loam is 18 to 40 inches, and spots of Sims soils, which are in depressions and drainageways and are more poorly drained and darker colored than Kawkawlin soils.

Fertility is high, the organic-matter content is medium, the available water capacity is high, runoff is slow, and permeability is moderate.

If drained artificially this soil is well suited to most crops. Intensive cropping systems that emphasize row crops are common. (Capability unit IIw–2 (1.5b); woodland suitability group Z)

Kawkawlin loam, 2 to 6 percent slopes (KnB).—This soil is on till plains and uplands. On the uplands it occupies the lower part of slopes and the concave margins of areas of wetter soils. On the till plains it has an irregular surface characterized by low knolls and shallow depressions. Associated with this soil are Nester soils, which are well drained, and Sims soils, which are poorly drained.

This Kawkawlin soil has the profile described as typical of the series. In some places the texture of the surface layer is silt loam instead of loam, and in others it is sandy loam. Included in mapping were spots of Belding soils, in which the depth to clay loam is 18 to 40 inches, and spots of better drained, lighter colored Nester soils that have slopes of more than 6 percent.

Fertility is high, the organic-matter content is medium, and the available water capacity is high. Runoff is slow, and water ponds in low areas.

If artificially drained this soil is well suited to crops. Most of the acreage is cultivated. (Capability unit IIw–3 (1.5b); woodland suitability group Z)

Kibbie Series

The Kibbie series consists of somewhat poorly drained soils that occur on lake plains and outwash plains, mainly in the eastern part of the county. These soils developed in layers of silt, silt loam, and very fine sand.

In a typical profile, the surface layer consists of very dark grayish-brown loam and is about 10 inches thick. The subsoil is about 20 inches thick. The upper 10 inches is brown, mottled, friable heavy silt loam, and the lower 10 inches is light yellowish-brown, mottled, friable silt loam. The underlying material, at a depth of 30 inches, is made up of layers of very pale brown silt and very fine sand; it extends to a depth of several feet.

Fertility is medium, the available water capacity is high, permeability is moderate, and runoff is slow. The soils are seasonally wet, and artificial drainage is needed for most crops. Installation and maintenance of drainage systems are difficult because the soil material is unstable, especially when wet.

Most areas of Kibbie soils have been cleared and are used for crops. Some are idle, some are used for hay or pasture, and some are still wooded. The native vegetation is a mixture of hardwoods, including elm, ash, maple, aspen, and beech.

Typical profile of Kibbie loam, 0 to 2 percent slopes, cultivated, located in the SE¼SE¼SW¼ sec. 8, T. 5 N. R. 13 W. (Jamestown Township):

Ap—0 to 10 inches, very dark grayish-brown (10YR 3/2) loam; moderate, medium, granular structure; friable; neutral; abrupt, smooth boundary.

B21t—10 to 20 inches, brown (10YR 5/3) heavy silt loam; many, medium, distinct, light-gray (10YR 7/2) mottles and few medium, distinct, brownish-yellow (10YR 6/6) mottles; moderate, medium, subangular blocky structure; friable to firm; slightly acid; clear, wavy boundary.

B22—20 to 30 inches, light yellowish-brown (10YR 6/4) silt loam; many, medium and coarse, distinct, light-gray (10YR 7/1–7/2) mottles; moderate, medium, platy structure; friable; mildly alkaline; clear, wavy boundary.

C—30 to 50 inches, very pale brown (10YR 7/4) silt and very fine sand; few, medium, distinct, light-gray (10YR 7/1) mottles; moderate, medium, platy structure; friable; moderately alkaline.

The solum is 24 to 48 inches thick. In reaction it ranges from slightly acid to mildly alkaline.

In undisturbed areas the profile has an A1 and an A2 horizon instead of an Ap horizon. The A1 horizon is very dark gray (10YR 3/1) and is 4 to 6 inches thick. The A2 is grayish brown (10YR 5/2) or dark grayish brown (10YR 4/2) and is 2 to 6 inches thick. A thin A2 horizon occurs in some cultivated areas.

In some areas the profile includes a 2- to 6-inch B horizon that is free of mottling or nearly so.

In the B horizon the color ranges to grayish brown (10YR 5/2) or yellowish brown (10YR 5/4). The mottles in the B horizon are dominantly light gray (10YR 7/1–7/2), gray (10YR 6/1–5/1), light brownish gray (10YR 6/2), or grayish brown (10YR 6/2). The texture of this horizon is light clay loam, silty clay loam, silt loam, or loam.

Thin strata of clay occur in the C horizon in some profiles. The reaction is mildly alkaline in places.

Kibbie soils and Tuscola soils formed in similar material. Kibbie soils are less well drained than Tuscola soils, and they have gray mottles in the B2 horizon, which Tuscola soils lack. Kibbie soils are in the same drainage class as Conover soils, which lack the stratification in the C horizon that is characteristic of Kibbie soils.

Kibbie loam, 0 to 2 percent slopes (KoA).—This soil occurs on lake plains and outwash plains. Most areas are in the eastern part of the county. Those in the southeastern part are near areas of Blount and Morley soils, and those in the northeastern part are near areas of Nester, Bowers, and Kawkawlin soils.

This Kibbie soil has the profile described as typical of the series, but variations in the profile occur from place to place. In areas north of Highway M–21, the upper part of the subsoil is redder than is typical and in places the profile contains two separate subsoils. In some places the texture of the surface layer is silt loam, fine sandy loam, or sandy loam, and in a few places a layer of silty clay occurs at a depth of 3 to 4 feet. Included in mapping were spots of Blount soils; of Bruce and Hettinger soils, which are more poorly drained; and of Tuscola and Morley soils, which are better drained.

Fertility is medium, and the available water capacity is high. Excessive wetness in spring and early in summer limits the use of farm machinery and restricts the growth of plants. Installation and maintenance of drainage systems are difficult because of the unstable nature of the soil material.

If drained artificially this soil is well suited to crops. The instability of the soil material is a limitation in construction. (Capability unit IIw–6 (2.5b); woodland suitability group G)

Kibbie loam, 2 to 6 percent slopes (KoB).—This soil is on lake plains, at the margins of outwash plains. Most areas are in the eastern part of the county. Those in the southeastern part are near areas of Blount and Morley soils, and those in the northeastern part are near areas of Nester, Bowers, and Kawkawlin soils.

In some areas, mainly north of Highway M–21, the upper part of the subsoil is brighter colored than is typical and in places the profile contains two separate subsoils. In some places the surface layer is silt loam, fine sandy loam, sandy loam, or loamy fine sand. In eroded areas the surface layer is dark grayish brown or dark brown. In a few areas in the lake plains, silty clay occurs at a depth of 3 to 4 feet. Included in mapping were spots of Blount soils; of more poorly drained Bruce and Sims soils in depressions and waterways; and of better drained Tuscola, Morley, and Nester soils that have slopes of more than 6 percent.

Fertility is medium, and the available water capacity is high. Excessive wetness in spring and early in summer limits the use of farm machinery and restricts the growth of plants. Installation and maintenance of drainage systems are difficult because of the unstable nature of the soil material. Erosion and soil blowing are hazards.

If drained artificially this soil is well suited to crops. Most areas are cultivated. Some are used mainly for hay or pasture, and a few for woodlots. The instability of the soil material is a limitation in construction. (Capability unit IIw–7 (2.5b); woodland suitability group G)

Lacota Series

The Lacota series consists of poorly drained soils on lake plains and outwash plains. These soils are underlain with sand and gravel at a depth of 18 to 40 inches. They occur most commonly where plains and uplands merge.

In a typical profile, the surface layer consists of very dark brown silt loam and is about 7 inches thick. The subsoil is about 23 inches thick. The uppermost 7 inches is dark grayish-brown, mottled, friable silt loam, and the rest is grayish-brown and very dark grayish-brown, mottled, firm light silty clay loam. The underlying material, at a depth of about 30 inches, is mottled grayish-brown, light olive-brown, and light yellowish-brown, limy heavy silt loam over light brownish-gray, mottled, limy sand and fine gravel.

Fertility is high, the available water capacity is moderate, and runoff is very slow to ponded. Permeability is moderate in the upper layers and rapid in the underlying sand and gravel. The dull, grayish colors of the subsoil are evidence of excessive wetness during much of the year. Artificial drainage is needed for most crops. Frost damage to crops is a hazard.

These soils are moderately well suited to crops if drained. Most areas have been cleared and cultivated, but many are now idle or in pasture. Some are still wooded. The native vegetation is a mixture of lowland hardwoods, including elm, ash, swamp white oak, cottonwood, red maple, and some sycamore.

Typical profile of Lacota silt loam, cultivated, located in the SW¼NE¼NW¼ sec. 16, T. 6 N., R. 13 W. (Georgetown Township):

Ap—0 to 7 inches, very dark brown (10YR 2/2) silt loam; weak, medium, subangular blocky structure; friable to firm; mildly alkaline; abrupt, smooth boundary.

B21g—7 to 14 inches, dark grayish-brown (2.5Y 4/2) silt loam; common, medium, distinct, very dark grayish-brown (10YR 3/2) mottles; weak, medium, subangular blocky structure; friable; neutral; clear, wavy boundary.

B22g—14 to 22 inches, grayish-brown (10YR 5/2) light silty clay loam; many, fine, faint, light brownish-gray (10YR 6/2) mottles; weak, medium, subangular blocky structure; firm; neutral; clear, wavy boundary.

B23g—22 to 30 inches, grayish-brown (2.5Y 5/2) and very dark grayish-brown (10YR 3/2) light silty clay loam; few, medium, distinct, olive (5Y 5/6) mottles; weak, medium, angular blocky structure; firm; mildly alkaline; gradual, wavy boundary.

C1g—30 to 38 inches, mottled grayish-brown (2.5Y 5/2), light olive-brown (2.5Y 5/6), and light yellowish-brown (2.5Y 6/4) heavy silt loam; massive; friable to firm; calcareous; abrupt, smooth boundary.

IIC2—38 to 66 inches, light brownish-gray (10YR 6/2) sand and fine gravel; common, fine, distinct, dark greenish-gray (5GY 4/1) mottles; single grain; loose; calcareous.

The depth to the IIC2 horizon ranges from 18 to 40 inches but most commonly is between 24 and 38 inches. The reaction of the solum ranges from slightly acid to mildly alkaline.

In undisturbed areas there is a black (10YR 2/1) A1 horizon 5 to 12 inches thick and in some places a black organic surface layer less than 12 inches thick. In some cultivated areas an A1 horizon of black (10YR 2/1) or very dark brown (10YR 2/2) silt loam occurs below the Ap horizon.

In the Bg horizon the color has a hue of 10YR or 2.5Y, a value of 3 to 6, and a chroma of 1 or 2. In some profiles this horizon is not mottled. The texture is loam, silt loam, light silty clay loam, or clay loam. The weighted average clay content ranges from about 18 to 25 percent.

The reaction of the C1g and IIC2 horizons ranges from neutral to moderately alkaline. In some profiles these horizons are not calcareous.

Lacota soils are in the same drainage class as Gilford and Sims soils. They have a finer textured B2g horizon than Gilford soils, and they have a sand and gravel IIC2 horizon, which Sims soils lack.

Lacota silt loam (0 to 2 percent slopes) (lc).—This level to depressional soil is on outwash plains and lake plains and in major drainageways. Many areas are at the margins of plains, where plains and uplands merge. Nester, Ubly, and Morley soils commonly occur on the adjacent uplands, and Gilford, Tonkey, and Gladwin soils occur nearby on the plains.

In some places the surface layer is loam, fine sandy loam, or sandy loam, and in some the texture is predominantly clay loam to a depth of 18 to 40 inches. The underlying sand and gravel in some places contains thin layers of silt and clay, and in other places it contains lenses of silt and clay that are 2 to 4 inches in diameter. Included in mapping were spots of Sims and Hettinger soils, in which the depth to the underlying material is more than 40 inches, and of Tonkey soils, in which loamy material extends to a depth of less than 18 inches. Also included were ridges that have slopes of more than 2 percent.

Fertility is high, the available water capacity is moderate, and runoff is very slow to ponded. Artificial drainage is needed for most crops. Frost damage to crops is a hazard.

Most areas of this soil have been cleared and are cultivated. Some are in pasture, and some are still wooded. (Capability unit IIw–6 (3c); woodland suitability group W)

Lake Beaches

Lake beaches (lb) consists of grayish-brown to light-gray sand that shows no horizon differentiation. It occurs along Lake Michigan and also along inland bodies of water. Generally it slopes very gently from the water level up to an elevation of as much as 15 feet higher, but in some places the slopes are short and steep. The lowest parts are intermittently covered with water. Wind action results in a changing pattern of low humps and pits in dry areas. Along Lake Michigan, the sand is calcareous; along the inland bodies of water, it is noncalcareous.

Recreation is the principal use. Cottages have been built in a few places. Beachgrass grows near the water in some areas, and a few scattered trees in some, but many areas have no vegetation. (Capability unit VIIIs–1 (Sa); woodland suitability group Y)

Linwood Series

The Linwood series consists of nearly level to depressional, very poorly drained soils on till plains, lake plains, and moraines. These soils consist of woody and fibrous organic material and are underlain at a depth of 12 to 42 inches with mineral soil.

In a typical profile, the surface layer consists of very dark brown, well-decomposed muck and is about 12 inches thick. Below this is a 6-inch layer of very dark grayish-brown, partly decomposed mucky peat; a 6-inch layer of very dark brown, finely divided peat; and a 6-inch layer of dark-brown, fibrous peat. The underlying material, at a depth of 30 inches, is gray, mottled loam.

Fertility is low, and the available water capacity is high. Permeability is rapid in the organic material and moderate in the underlying loam. Runoff is slow to ponded, and water runs off adjacent higher areas onto these soils. The water table is at the surface unless lowered by artificial drainage. Establishing drainage is difficult, and the organic material is likely to settle and decompose if drained and cultivated.

Some areas of Linwood soils have been cleared and are cultivated. Others are still wooded. The native vegetation is a mixture of lowland hardwoods, including elm, ash, swamp white oak, cottonwood, red maple, silver maple, and some sycamore. The trees are shallow rooted and of low quality.

Typical profile of Linwood muck, undisturbed, located in the SE¼SE¼NE¼ sec. 1, T. 9 N., R. 13 W. (Chester Township):

1—0 to 12 inches, very dark brown (10YR 2/2), well-decomposed muck; moderate, medium, granular structure; friable; medium acid; clear, smooth boundary.

2—12 to 18 inches, very dark grayish-brown (10YR 3/2), partly decomposed, woody mucky peat; weak, medium, granular structure; friable; medium acid; clear, wavy boundary.

3—18 to 24 inches, very dark brown (10YR 2/2), finely divided, gelatinous peat; massive; friable; strongly acid; clear, smooth boundary.

4—24 to 30 inches, dark-brown (10YR 3/3), fibrous peat; massive; friable; strongly acid; clear, smooth boundary.

IICg—30 to 50 inches, gray (10YR 5/1) loam; few, fine, distinct, pale-brown (10YR 6/3) and common, coarse, distinct, very dark gray (10YR 3/1) mottles; massive; friable; very dark gray (10YR 3/1) mottles are organic stains; medium acid.

The organic material is 12 to 42 inches thick. In reaction it ranges from strongly acid to neutral but is most commonly medium acid or slightly acid. In some places the organic material is predominantly woody, and in others it is partly woody and partly fibrous.

The IIC horizon is medium acid to moderately alkaline in reaction and is calcareous in places. In texture this horizon ranges from sandy loam to silty clay loam.

Linwood soils are similar to Adrian, Edwards, and Carlisle soils. Linwood soils have a IICg horizon of loam, Adrian soils a IIC horizon of loamy sand and sand, and Edwards soils a IIC horizon of marl. In Linwood soils the organic deposit is 12 to 42 inches thick, and in Carlisle soils it is more than 42 inches thick.

Linwood muck (0 to 2 percent slopes) (ls).—This soil occurs in small depressions on moraines and on low, wet flats within till plains and lake plains. It is associated with mineral soils of loamy texture.

Typically, the organic deposit is thin at the edges of an area and thicker toward the center. Some areas are rimmed with mineral soils that have a mucky surface layer, and

small spots of deep organic soils occur in places. In areas that have been drained and cultivated for some time, the organic deposit has been thinned by blowing, settling, and decomposition. Included in mapping were small areas in which layers of mineral soil and organic material alternate, and spots where the underlying material is sandy. Also included were areas that have slopes of more than 2 percent.

Fertility is low, and the available water capacity is high. Cultivated areas are susceptible to soil blowing. Artificial drainage is difficult because of the variable thickness of the organic deposit. Drainage and special fertilization are needed to grow crops successfully.

Individual areas are small, and most are with other soils in fields in which corn is grown. A few undrained areas are covered with trees or brush. (Capability unit IIIw–15 (M/3c); woodland suitability group U)

Made Land

Made land (Ma) consists of soils that have been covered with fill and soils that have been scraped to such a depth that the characteristics of the original profile are obliterated. Sanitary land fills, borrow pits, and prospective building sites are among the kinds of areas in the mapping unit. The composition of the soil material varies. Individual areas differ greatly in size; some are too small to be shown separately on the soil map and are identified by a spot symbol.

Made land is not suitable for farming. (Capability unit VIIIs–1 (Sa); no woodland suitability classification)

Mancelona Series

The Mancelona series consists of well drained and moderately well drained soils that occur on outwash plains and on uplands. These soils are underlain at a depth of 18 to 40 inches with limy sand and gravel.

In a typical profile, the surface layer consists of very dark grayish-brown loamy sand and is about 7 inches thick. The subsoil is about 27 inches thick. It is made up of 7 inches of brown, friable light sandy loam; 10 inches of strong-brown, very friable loamy sand; 6 inches of light yellowish-brown, loose coarse sand; and 4 inches of dark yellowish-brown, firm sandy clay loam. The underlying material, at a depth of 34 inches, is pale-brown, limy coarse sand and gravel.

Fertility is low, and the available water capacity is low. Permeability is moderate in the subsoil and very rapid in the underlying material. Runoff is very slow to moderate, depending on the slope. The organic-matter content is low. The soils are susceptible to water erosion and to blowing.

Many areas of Mancelona soils have been cleared and are cultivated. Corn, small grain, and hay are the common crops. Some areas are now idle, some are used for pasture, some are still wooded, and still others are supplying sand and gravel. The native vegetation is a mixture of hardwoods and conifers; it includes oak, aspen, hard maple, beech, and some white pine. At one time there were some dense stands of white pine. Some areas formerly used for crops have been planted to red pine and white pine for timber or to Scotch pine for Christmas trees.

Typical profile of Mancelona loamy sand, 0 to 2 percent slopes, cultivated, located in the NW¼NW¼SE¼NW¼ sec. 29, T. 5 N., R 14 W. (Zeeland Township)

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, granular structure; very friable; slightly acid; abrupt, smooth boundary.

B21ir—7 to 14 inches, brown (7.5YR 4/4) light sandy loam; weak, coarse, subangular blocky structure; friable; strongly acid; gradual, wavy boundary.

B22ir—14 to 24 inches, strong-brown (7.5YR 5/6) loamy sand; weak, coarse, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

A'2—24 to 30 inches, light yellowish-brown (10YR 6/4) coarse sand; single grain; loose; medium acid; clear, wavy boundary.

B't—30 to 34 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; massive, breaking to weak, coarse, subangular blocky structure; firm; medium acid; clear, irregular boundary.

IIC—34 to 66 inches, pale-brown (10YR 6/3) coarse sand and gravel; single grain; loose; calcareous.

The solum is 18 to 40 inches thick and most commonly is more than 24 inches thick. The reaction of the A and B2ir horizons ranges from strongly acid to slightly acid, and that of the A'2 and B't horizons from medium acid to neutral. Varying amounts of gravel occur within the solum. Some profiles are mottled at a depth of about 30 inches.

In undisturbed areas the profile has an A1 horizon and an A2 horizon instead of an Ap. The A1 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) and is 2 to 5 inches thick. The A2 is grayish brown (10YR 5/2) or light brownish gray (10YR 6/2) and is 2 to 6 inches thick.

The color of the Ap horizon ranges to dark grayish brown (10YR 4/2) or very dark gray (10YR 3/1). In some cultivated areas the profile includes a thin A2 horizon of sand, loamy sand, or sandy loam.

In the B1r horizon the color ranges to dark yellowish brown (10YR 4/4 or 4/3), and the texture is sand, loamy sand, or sandy loam. In some places the profile includes a dark reddish-brown (5YR 3/2–3/3–3/4 or 2.5YR 3/4) Bhir horizon that is 2 to 4 inches thick. The color of the A'2 horizon ranges to pale brown (10YR 6/3), and the texture is sand or loamy sand. The color of the B't horizon ranges to brown (7.5YR 4/4) or strong brown (7.5YR 5/6), and the texture is sandy clay loam or sandy loam.

The IIC horizon is dominantly sand in some places, dominantly gravel in others, and stratified in still others. In some profiles the reaction is neutral in the uppermost 6 to 8 inches of the IIC horizon.

Mancelona soils occur near Chelsea and Montcalm soils. They differ from these associated soils in having a IIC horizon of limy sand and gravel. Mancelona soils formed in the same kind of material as Gladwin soils. They occur at higher elevations than Gladwin soils and are better drained.

Mancelona loamy sand, 0 to 2 percent slopes (McA).—This soil occurs on outwash plains and on upland hilltops and benches. In general, the areas on the plains are larger than those on the uplands. Associated with this soil are somewhat poorly drained Gladwin soils and poorly drained Gilford soils, both of which occur in drainageways and depressions.

This Mancelona soil has the profile described as typical of the series, but variations in the profile occur from place to place. In undisturbed areas there is a darker colored surface layer 2 to 5 inches thick and a grayish-brown subsurface layer. Mottling occurs in the lower part of the subsoil in some places. Included in mapping were spots of Newaygo soils, which have a thicker and finer textured subsoil than this Mancelona soil; spots of darker colored, less well drained Gladwin soils in depressions and drainageways; spots in which the depth to the limy underlying material is less than 18 inches or more than 40

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inches; and some areas that have slopes of more than 2 percent.

Fertility is low, the available water capacity is low, and runoff is very slow. The organic-matter content is low. The water table fluctuate and is within 4 feet of the surface after long periods of wet weather. The soil warms up and dries out fairly early in spring but then becomes droughty in summer. Soil blowing is a hazard if the surface is exposed.

This soil is used for crops and pasture. It is fairly well suited to the common crops if well managed. Long cropping systems that emphasize close-growing and early-maturing crops are usual (fig. 9). Some areas are idle, some remain wooded, and still others are supplying sand and gravel. Limitations for construction are few. (Capability unit IIIs-3 (4a) ; woodland suitability group C)

Mancelona loamy sand, 2 to 6 percent slopes (McB).—This soil is on outwash plains, terraces, and uplands. The upland areas are smaller than those in other locations. Slopes are generally less than 300 feet long. Associated with this soil are somewhat poorly drained Gladwin soils and poorly drained Gilford soils, both of which are in drainageways and depressions.

In wooded areas and other undisturbed areas, there is a darker colored surface layer 2 to 5 inches thick and a grayish-brown subsurface layer. Mottling occurs in the lower part of the subsoil in some places. In areas that have been cultivated and are eroded, the present surface layer is a mixture of what were originally the uppermost three layers and commonly consists of dark-brown loamy sand or light sandy loam. In places the gravelly underlying material is within 2 feet of the surface. Included in mapping were areas of darker colored, more poorly drained Gladwin soils that have slopes of less than 2 percent; spots of Newaygo soils, which are finer textured than Mancelona soils; spots of Chelsea and Rubicon soils; and some areas that have slopes of more than 6 percent.

Fertility is low, the available water capacity is low, and runoff is slow. The organic-matter content is low. The soil warms up and dries out fairly early in spring and is droughty in summer. Soil blowing is a hazard if the surface is exposed.

This soil is fairly well suited to most crops if well managed. Most areas are used for crops. Long cropping systems that emphasize close-growing and early-maturing crops are usual. Some areas are now idle, some are supplying sand and gravel, and some have been planted to pine for timber or for Christmas trees. Limitations for construction are few. (Capability unit IIIs–4 (4a) ; woodland suitability group C)

Mancelona loamy sand, 6 to 12 percent slopes (McC).—Some areas of this soil occupy hillsides and hilltops on uplands, and some occupy long, narrow breaks on outwash plains and on terraces. On the uplands, the slopes are irregular and knolls and pockets are common. On the outwash plains and terraces, the slopes are long and fairly uniform.

The plow layer typically is dark grayish-brown sandy loam or loamy sand. In places the depth to the gravelly underlying material is only 2 feet. Included in mapping were severely eroded areas in which brownish sand or loamy sand predominates; areas of eroded soils that resemble Newaygo soils, in which the surface layer is dark-brown or dark reddish-brown sandy clay loam that is hard and crusted when dry; spots of soils that have a sandy loam surface layer and subsoil and resemble Fox soils; wet spots occupied by Gladwin soils; areas of Rubicon and Chelsea soils on knolls; and some areas that have slopes of more than 12 percent.

Fertility is low, the available water capacity is low, and

Figure 9.—**Typical scene in an area of Mancelona loamy sand, 0 to 2 percent slopes.**

runoff is slow. The organic-matter content is low. The soil is susceptible to water erosion and to blowing.

Most areas of this soil have been cleared and cultivated, but some are now idle, some are used only for hay and pasture, and some have been planted to pine for timber or for Christmas trees. Crops, mainly corn, small grain, and hay, are still grown in a few areas. Long rotations that consist largely of close-growing and early-maturing crops are usual. (Capability unit IIIe–9 (4a); woodland suitability group C)

Marsh

Marsh (Me) is made up of old bayous and other wet areas along distributaries of streams that flow into Lake Michigan and of extremely wet inland areas along the margins of old lakes and on bottom lands.

The soil material is pasty, finely divided peat. It is saturated continuously, and it will not support weight. The vegetation consists of cattails, sedges, water-loving herbaceous plants, and scattered clumps of water-tolerant trees, including tamarack, willow, hoary alder, and dogwood.

Most areas of Marsh are useful only as habitat for waterfowl, muskrats, and other birds and animals that need a wetland environment. A few small selected areas have been diked and drained and are used to grow specialty crops, mainly flowers, bulbs, celery, and melons. Drainage and reclamation are very expensive and should be undertaken only after a feasibility study. (Capability unit VIIIw–2 (Sc); woodland suitability group U)

Matherton Series

The Matherton series consists of somewhat poorly drained soils that occur on outwash plains, in drainageways, and on terraces. These soils developed in 24 to 40 inches of sandy loam to clay loam underlain with loose sand and gravel.

In a typical profile, the surface layer consists of very dark brown loam and is about 10 inches thick. The subsoil is about 30 inches thick. The uppermost 15 inches is brown, mottled, friable sandy loam; the next 4 inches is dark grayish-brown, mottled, friable light sandy loam; and the lowermost 11 inches is dark reddish-brown, mottled, firm gravelly clay loam. The underlying material, at a depth of 40 inches, consists of yellowish-brown sand over light yellowish-brown, limy sand and fine gravel.

Fertility is medium, the available water capacity is moderate, and runoff is slow to ponded. The water table rises to within 2 feet of the surface during prolonged periods of wet weather. Except when the water table is high, permeability is moderate in the upper 24 to 40 inches of the profile and very rapid in the underlying material.

Matherton soils are well suited to crops if adequately drained. Most areas have been cleared and drained and are cultivated. Some areas that are inadequately drained and some that are not drained are used for pasture. Some are still wooded. The native vegetation consists mainly of lowland hardwoods, including maple, elm, ash, oak, and birch; it also contains some white pine. A few areas are sources of sand and gravel.

Typical profile of Matherton loam, cultivated, located in the SE. corner of sec. 24, T. 6 N., R. 13 W. (Georgetown Township):

Ap—0 to 10 inches, very dark brown (10YR 2/2) loam; weak, medium, granular structure; friable; mildly alkaline; abrupt, smooth boundary.

B1—10 to 25 inches, brown (10YR 5/3) sandy loam; few, medium, faint, dark-gray (10YR 4/1) mottles below a depth of 12 inches; weak, medium, subangular blocky structure; friable; neutral; clear, wavy boundary.

B21tg—25 to 29 inches, dark grayish-brown (10YR 4/2) light sandy clay loam; few, medium, faint, brown (10YR 5/3) mottles; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B22tg—29 to 40 inches, dark reddish-brown (5YR 3/2) gravelly clay loam; many, medium, distinct, pale-brown (10YR 5/3) mottles; moderate, medium, subangular blocky structure; firm; slightly acid, grading to neutral in the lower part; clear, wavy boundary.

IIC1—40 to 44 inches, yellowish-brown (10YR 5/6) sand; many, medium, distinct, grayish-brown (10YR 5/2) mottles; single grain; loose; mildly alkaline; gradual, wavy boundary.

IIC2—44 to 66 inches, light yellowish-brown (10YR 6/4) sand and fine gravel; single grain; loose; moderately alkaline and calcareous.

The solum is 24 to 40 inches thick over the coarse-textured IIC horizon. In reaction the solum ranges from strongly acid to mildly alkaline but is predominantly medium acid or slightly acid.

In undisturbed areas the profile has a 3- to 6-inch A1 horizon of black (10YR 2/1) silt loam, loam, or sandy loam. A layer of organic material 3 to 5 inches thick covers the surface in some slightly depressed areas.

The color of the Ap horizon ranges to black (10YR 2/1) or very dark gray (10YR 3/1), and the texture is silt loam or loam instead of sandy loam in some places.

The texture of the B1 horizon is silt loam instead of sandy loam in places. The color of the B2 horizon ranges to grayish brown (10YR 5/2), and the texture ranges from silty clay loam to sandy clay loam. In some profiles the B2 horizon is gravelly. Tongues of B2 material extend down into the IIC horizon in some places.

The reaction of the IIC horizon ranges from neutral to moderately alkaline. In some profiles there is no free lime above a depth of 66 inches. Strata of sand and gravel and thin, discontinuous layers of silty material occur in this horizon in some places.

Matherton soils and Fox soils formed in similar material and occur near together. Matherton soils are at lower elevations than Fox soils, are less well drained, and have mottles in the B2 horizon. Matherton soils also occur near Gladwin and Gilford soils. They have a thicker and finer textured B2 horizon than either Gladwin or Gilford soils, and they are less poorly drained than Gilford soils.

Matherton loam, 0 to 2 percent slopes (MhA).—This soil occurs throughout the county on outwash plains, on terraces, in old drainageways, and, to a limited extent, on lake plains. Associated with it are Mancelona and Fox soils, which are at higher elevations and are better drained; Lacota and Gilford soils, which are at lower elevations and are more poorly drained; and Nester, Iosco, and Kawkawlin soils, which are at the edge of the uplands.

The surface layer of this Matherton soil is very dark brown loam or very dark gray silt loam or sandy loam. In the northern part of the county are areas of this soil in which the upper part of the subsoil contains more iron than is typical and consequently has a redder hue. In scattered areas the texture throughout the profile is predominantly loam and clay loam and the depth to the underlying material is more than 40 inches. Also, in the glacial drainageway in the northeastern part of the county, the depth to the underlying material is more than 40 inches. In some places the underlying material consists of layers of sand, sandy loam, and silty material. Included

in mapping were a few areas in which the slope is more than 2 percent. Some of these areas are eroded and now have a surface layer of dark grayish-brown sandy loam or sandy clay loam. Other inclusions are spots of Gladwin soils, which are coarser textured in the upper part of the profile; spots of Wasepi soils, in which limy material is within 24 inches of the surface; small areas of Lacota and Gilford soils, which are in depressions and drainageways and are wetter and darker colored than Matherton soils; and spots of Tonkey soils, in which layers of sandy loam and sand occur below a depth of 3 feet.

Fertility is medium, the available water capacity is moderate, and runoff is slow to ponded. The water table rises to within 2 feet of the surface during long periods of wet weather but is much lower at other times. Except when the water table is high, permeability is moderate in the upper part of the profile and very rapid in the underlying material. Artificial drainage is needed for most crops. Drainage systems are difficult to install and maintain because of the loose underlying material; ditchbanks are unstable, and tile lines fill up with sand. Frost is a hazard to crops in some areas.

If drained this soil is suited to most crops. Most areas have been cleared and drained and are cultivated. Corn, small grain, and hay are the common crops. Some of the undrained areas are used for native pasture, and a few are still wooded. Sand and gravel are being obtained from a few areas. (Capabliity unit IIw–6 (3b); woodland suitability group G)

Menominee Series

The Menominee series consists of well drained and moderately well drained soils on uplands. These soils developed in 18 to 40 inches of sand or loamy sand and are underlain with limy clay loam.

In a typical profile, the surface layer consists of very dark grayish-brown loamy sand and is about 7 inches thick. The subsoil is about 28 inches thick. It is made up of 4 inches of reddish-brown, very friable loamy sand; 11 inches of strong-brown, very friable loamy sand; 10 inches of light yellowish-brown, loose sand; and 3 inches of brown, friable sandy clay loam. The underlying material, at a depth of 35 inches, is grayish-brown, mottled, limy clay loam.

Fertility is low, and the available water capacity is moderate. Runoff varies, depending on the slope and the vegetation. Permeability is rapid in the surface layer and subsoil and moderately slow in the underlying material. The organic-matter content is low. Water erosion and soil blowing are hazards.

Most areas of Menominee soils have been cleared and are cultivated. Corn, small grain, and hay are common crops. Some areas are now idle, and others are used for hay and pasture. Some are still wooded. The native vegetation consists of a mixture of hardwoods and conifers, including hard maple, oak, aspen, and white pine.

Typical profile of Menominee loamy sand, 2 to 6 percent slopes, cultivated, located in the SE¼SE¼SE¼ sec. 32, T. 9 N., R. 13 W. (Chester Township):

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, granular structure; very friable; neutral; abrupt, smooth boundary.

B21ir—7 to 11 inches, reddish-brown (5YR 4/4) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B22ir—11 to 22 inches, strong-brown (7.5YR 5/6) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; gradual, wavy boundary.

A'2&B21t—22 to 32 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; a few ¼-inch to ½-inch bands of yellowish-brown (10YR 5/6), massive loamy sand; medium acid; clear, wavy boundary.

IIB'22t—32 to 35 inches, brown (7.5YR 4/4) sandy clay loam; massive; friable; neutral; clear, wavy boundary.

IIC—35 to 66 inches, grayish-brown (10YR 5/2) clay loam; few, medium, distinct, yellowish-brown (10YR 5/6) mottles; moderate, medium, subangular blocky structure; firm; calcareous.

The depth to the IIB'22t horizon ranges from 18 to 40 inches. In the layers between the Ap horizon and the IIB'22t horizon, the reaction ranges from slightly acid to strongly acid and is most commonly medium acid or strongly acid.

In undisturbed areas the profile has an A1 and an A2 horizon instead of an Ap horizon. The A1 horizon is very dark gray (10YR 3/1) and is 1 to 3 inches thick. The A2 is gray (10YR 5/1) to light brownish gray (10YR 6/2) and is 4 to 8 inches thick.

The color of the Ap horizon in some areas is dark grayish brown (10YR 4/2).

In the Bir horizon the color ranges to dark brown (7.5YR 4/4) or dark yellowish brown (10YR 4/4). Some profiles lack the A'2&B21t horizon. In some places where the A'2&B21t horizon is lacking, there is an A'2 horizon, as much as 10 inches thick, between the Bir and the IIB'22t horizons. This A'2 horizon is pale brown (10YR 6/3) to light brownish gray (10YR 6/2). In some places it is slightly brittle. The color of the IIB'22t horizon ranges to reddish brown (5YR 4/4), and the texture is sandy clay loam, loam, clay loam, or silty clay loam.

The texture of the IIC horizon is silty clay loam in some places. This horizon is not mottled in all places.

Menominee soils and Iosco soils formed in similar material. Menominee soils are better drained than Iosco soils and lack the mottles in the upper part of the B horizon that are characteristic of Iosco soils. Menominee soils are similar to Ubly soils but have a coarser textured Bir horizon.

Menominee loamy sand, 2 to 6 percent slopes (MmB).—This soil occurs on knolls and in depressions on uplands.

This soil has the profile described as typical of the series, but variations from the typical profile occur from place to place. In a few scattered areas, the underlying material is finer textured than is typical. In places the texture of the surface layer is sandy loam or fine sandy loam. Also in a few places the texture is sand or loamy sand to a depth of 18 to 40 inches and there is no finer textured layer in the subsoil. The depressions include spots of Chelsea and Rubicon soils, and the knolls include spots of Ubly and Nester soils. Deeper depressions are occupied by Belding and Iosco soils. Other inclusions are some areas of nearly level soils and some eroded spots in which the surface layer is dark-brown sand or loamy sand and the limy underlying material is commonly within 2 feet of the surface.

Fertility is low, and the available water capacity is moderate. The organic-matter content is low. This soil is droughty in long periods of dry weather, and it is susceptible to water erosion and to blowing.

Most areas of this soil are small, and their use commonly depends on the use of the surrounding soils. Most of the acreage is part of cultivated fields, but some is part of idle areas. (Capability unit IIIs–4 (4/2a); woodland suitability group C)

Menominee loamy sand, 6 to 12 percent slopes (MmC).—This soil occurs on uplands, where it occupies rounded ridges and knolls and short breaks to natural drainageways.

The plow layer is dark grayish brown. In some places it is sand instead of loamy sand. The depth to the limy underlying material is less than 36 inches in most places. In some eroded areas the surface layer is reddish brown or strong brown, and in others clay loam or silty clay loam is at the surface. Included in mapping were spots of Ubly soils, which are slightly finer textured in the uppermost 2 feet of the profile, and spots of Allendale and Iosco soils, which are finer textured in the lower part of the profile. Also included were some areas in which the slope is more than 12 percent.

Fertility is low, and the available water capacity is low. The organic-matter content is low. This soil is droughty in summer, and it is susceptible to water erosion and to blowing.

Areas of this soil are small, and their use commonly depends on the use of surrounding soils. Most of the acreage is in fields that are used for crops. (Capability unit IIIe–9 (4/2a); woodland suitability group C)

Metamora Series

The Metamora series consists of somewhat poorly drained soils that occur on till plains, on low moraines, and at the margin of lake plains. These soils are underlain with silty clay loam at a depth of 24 to 40 inches.

In a typical profile, the surface layer consists of very dark grayish-brown sandy loam and is about 7 inches thick. Below this is a 3-inch subsurface layer of light brownish-gray, mottled loamy sand. The subsoil is about 22 inches thick. It is made up of 8 inches of brown, mottled, very friable loamy sand; 7 inches of dark yellowish-brown, mottled, friable heavy sandy loam; 4 inches of pale-brown, mottled, very friable light sandy loam; and 3 inches of yellowish-brown, mottled, firm light sandy clay loam. The underlying material, at a depth of 32 inches, is grayish-brown, mottled, limy silty clay loam.

Fertility is medium, and the available water capacity is moderate. Permeability is moderately rapid in the surface layer and subsoil and moderately slow in the underlying material. The water table rises to within 2 feet of the surface during long periods of wet weather but recedes during dry weather. Seepage occurs at times.

If drained these soils are suited to most crops. Most areas have been cleared and drained and are cultivated. Corn, small grain, and hay are common crops. Undrained and inadequately drained areas are now idle or are used for hay and pasture. A few areas are still wooded. The native vegetation is a mixture of hardwoods, including elm, maple, birch, aspen, and oak.

Typical profile of Metamora sandy loam, 0 to 2 percent slopes, cultivated, located in the NW¼NE¼ sec. 33, T. 6 N., R. 13 W. (Georgetown Township, 200 feet east of Edison Road on Van Buren):

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

A2g—7 to 10 inches, light brownish-gray (10YR 6/2) loamy sand; many, medium, faint, gray (10YR 5/1) vertical streaks and blotches; weak, medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

B1—10 to 18 inches, brown (10YR 5/3) loamy sand; few, fine, faint, yellowish-brown (10YR 5/6) mottles; weak, coarse, subangular blocky structure; very friable; slightly acid; gradual, wavy boundary.

B21t—18 to 25 inches, dark yellowish-brown (10YR 4/4) heavy sandy loam; many, medium, distinct, grayish-brown (10YR 5/2) mottles and coatings on peds; moderate, medium, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.

B22t—25 to 29 inches, pale-brown (10YR 6/3) light sandy loam; many, medium, distinct, dark-brown (7.5YR 4/4) mottles; weak, medium, subangular blocky structure; very friable; neutral; clear, wavy boundary.

IIB23t—29 to 32 inches, yellowish-brown (10YR 5/4) light sandy clay loam; many, coarse, faint, light brownish-gray (10YR 6/2) mottles and coatings on peds and many, medium, prominent, yellowish-red (5YR 4/8) mottles; weak, medium, subangular blocky structure; firm; mildly alkaline; clear, wavy boundary.

IICg—32 to 60 inches, grayish-brown (2.5Y 5/2) silty clay loam; many, medium, distinct, yellowish-brown (10YR 5/8) mottles and many, fine, faint, olive-brown (2.5Y 4/4) mottles; strong, medium, angular blocky structure; firm; calcareous.

The solum is 24 to 40 inches thick. In reaction it ranges from medium acid to mildly alkaline.

In undisturbed areas there is an A1 horizon that is 3 to 6 inches thick and consists of very dark grayish-brown (10YR 3/2) or very dark gray (10YR 3/1) loam, sandy loam, or loamy sand.

The texture of the Ap horizon is sandy loam, loam, or loamy sand. The color of the A2g horizon ranges to grayish brown (10YR 5/2) or gray (10YR 5/1), and the texture is loamy sand or sandy loam.

The color of the B1 horizon ranges to grayish brown (10YR 5/2), and the texture is loamy sand or sandy loam. In the B21t horizon the color ranges to brown (10YR 5/3), grayish brown (10YR 5/2), and dark yellowish brown (10YR 4/3), and the texture is sandy loam or sandy clay loam. The color of the B22t horizon ranges to light brownish gray (10YR 6/2). In some profiles an A'2 horizon of loamy sand occurs below the B22t; this horizon is similar in color to the B22t horizon. In the IIB23t horizon the color ranges to dark brown (7.5YR 4/4) and the texture ranges to light clay loam.

The texture of the IICg horizon ranges from light clay loam to silty clay loam. The reaction in the uppermost 4 to 8 inches of this horizon is neutral.

Metamora soils are similar to Belding soils but lack the Bir horizon that is characteristic of Belding soils. Metamora soils occur near Blount and Kibbie soils. They are coarser textured in the upper part of the B2 horizon than Blount soils, and they have a finer textured C horizon than Kibbie soils.

Metamora sandy loam, 0 to 2 percent slopes (MnA).—This soil occurs on till plains and low moraines.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. In some areas the texture of the surface layer is sand, and in others it is loamy sand. In some places the subsoil contains a considerable amount of gravel, and in a few places a thin layer of limy sand and gravel occurs just above the substratum. In other places the texture is dominantly sandy loam to a depth of 24 to 40 or more inches. Included in mapping were spots of Iosco soils, which are coarser textured than this Metamora soil; spots of Kawkawlin soils, in which the depth to the underlying material varies and is less than 18 inches in places; and areas of Breckenridge and Sims soils in minor depressions and waterways. Other inclusions are areas in which the depth to the underlying material is more than 40 inches and some knolls and depressions where the slope is more than 2 percent.

Fertility is medium, and the available water capacity is moderate. Permeability is moderately rapid in the sur-

face layer and subsoil and moderately slow in the underlying material. The water table fluctuates. Artificial drainage is needed for most crops.

Most areas of this soil have been cleared and drained and are used for crops. Undrained areas are used for pasture and hay. A few areas are still wooded. (Capability unit IIw–8 (3/2b); woodland suitability group G)

Metamora sandy loam, 2 to 6 percent slopes (MnB).—This soil occurs on low moraines and at the margin of lake plains, where the plains and moraines merge. Associated with it are Blount, Breckenridge, and Morley soils.

The texture of the surface layer is loam in some areas and loamy sand in others. In places the subsoil contains a considerable amount of gravel, and in a few places a thin layer of limy sand or gravel occurs between the subsoil and the underlying material. In eroded fields the surface layer consists of brownish loamy sand and the depth to the limy underlying material is less than 24 inches. Included in mapping were spots of Ubly soils, which are better drained than Metamora soils; spots of Iosco soils, which are coarser textured; spots of Kawkawlin soils, in which the depth to the underlying material varies and is less than 18 inches in places; and areas of Breckenridge and Sims soils, which are in minor depressions and waterways. Also included were areas that have slopes of more than 6 percent; most of these are occupied by better drained soils but some are affected by seepage and are occupied by poorly drained Breckenridge soils. In other included soils the depth to the underlying material is more than 40 inches and sandy loam is the dominant texture in the upper part of the profile.

Fertility is medium, and the available water capacity is moderate. Because of a fluctuating high water table, artificial drainage is needed for most crops. The soil is susceptible to water erosion and to soil blowing.

If drained this soil is suitable for the common crops, but most areas are so small that their use depends on the use of the surrounding soils. Nearly all the acreage has been cleared and used for crops at some time, but now some is idle and some is used for hay and pasture. (Capability unit IIw–8 (3/2b); woodland suitability group G)

Miami Series

The Miami series consists of well-drained soils that occur in undulating to hilly areas in the southeastern part of the county.

In a typical profile, the surface layer consists of dark-brown loam and is about 6 inches thick. Below it is a 4-inch subsurface layer of brown loam. The subsoil, about 20 inches thick, consists of firm light clay loam; it is dark yellowish brown in the upper 6 inches and dark brown in the lower part. The underlying material, at a depth of 30 inches, is grayish-brown, limy loam.

Fertility is medium, the available water capacity is high, permeability is moderate, and runoff is moderate to rapid, depending on the slope.

Miami soils are well suited to most crops, and nearly all areas are used for crops. Only a few woodlots remain. The native vegetation is a mixture of upland hardwoods, including beech, maple, oak, and hickory.

Typical profile of Miami loam, 2 to 6 percent slopes, cultivated, located in the SE¼NE¼NE¼SE¼ sec. 10, T. 5 N., R. 13 W. (Jamestown Township):

Ap—0 to 6 inches, dark-brown (10YR 4/3) loam; weak, medium, granular structure; friable; neutral; abrupt, smooth boundary.

A2—6 to 10 inches, brown (10YR 5/3) loam; weak, medium, subangular blocky structure; friable; medium acid; gradual, wavy boundary.

B21t—10 to 16 inches, dark yellowish-brown (10YR 4/4) light clay loam; moderate, medium, subangular blocky structure; firm; medium acid; gradual, wavy boundary.

B22t—16 to 30 inches, dark-brown (10YR 4/3) light clay loam; strong, medium, angular blocky structure; firm; slighty acid; gradual, wavy boundary.

C—30 to 66 inches, grayish-brown (10YR 5/2) loam; moderate, medium, subangular blocky structure; friable; calcareous.

The solum is 24 to 42 inches thick. In reaction it ranges from strongly acid to neutral.

In undisturbed areas there is a 3- to 6-inch A1 horizon of very dark gray (10YR 3/1), very dark grayish-brown (10YR 3/2), or dark-gray (10YR 4/1) loam or sandy loam.

The texture of the Ap horizon is loam or sandy loam. The color of the A2 horizon ranges to grayish brown (10YR 5/2) or pale brown (10YR 6/3), and the texture is loam or sandy loam.

In the B horizon the color has a hue of 10YR, a value of 3, 4, or 5, and a chroma of 3 to 8. The texture of this horizon is light clay loam, clay loam, or light silty clay loam.

The color of the C horizon ranges to brown (10YR 5/3), yellowish brown (10YR 5/4), or pale brown (10YR 6/3), and the texture is loam or light clay loam.

Miami soils occur near Morley, Conover, and Owosso soils. Miami soils have a coarser textured C horizon than Morley soils; they are better drained than Conover soils and lack the mottles that are characteristic of Conover soils; and they have a finer textured B21t horizon than Owosso soils.

Miami loam, 2 to 6 percent slopes (MoB).—This soil is on hilltops and hillsides. The slopes vary from fairly uniform to irregular and complex. Associated with this soil are Morley, Conover, and Metamora soils.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. In slight depressions the surface layer is a little thicker and darker colored than is typical. In eroded areas the surface layer consists of dark yellowish-brown light clay loam that is low in organic-matter content and is hard and crusty when dry; the depth to the limy underlying material in these areas is about 24 inches. In areas at the lower elevations, the lower part of the subsoil is mottled. Included in mapping are spots of Owosso soils, which have a sandy loam subsoil; spots of Morley soils, which have a thicker and finer textured subsoil and substratum; and spots of Conover soils, which are in minor drainageways and depressions, are somewhat poorly drained, and have a darker colored surface layer.

Fertility is medium, the available water capacity is high, permeability is moderate, and runoff is medium. Erosion is a hazard if crops are grown.

Most of this soil is used for crops. Short cropping systems that include corn, small grain, and hay are usual. (Capability unit IIe–2 (2.5a); woodland suitability group D)

Miami loam, 6 to 12 percent slopes (MoC).—This soil occurs within an undulating to steep landscape in the southeastern part of the county. The slopes range from uniform and fairly long (though generally not more than 300 feet in length) to short, irregular, and complex. On the irregular slopes are small knolls and depressions. Associated with this soil are Morley, Conover, and Metamora soils.

In a few areas of this soil, the lower part of the subsoil is mottled. In other areas the texture is dominantly gravelly sandy loam to a depth of 18 to 40 inches. In eroded areas the surface layer is dark yellowish-brown or dark-brown clay loam that is very low in organic-matter content and is sticky when wet and hard and crusty when dry. Included in mapping were spots of Morley soils, which have a finer textured subsoil and substratum, and of Conover soils, which are in waterways and depressions and are less well drained and darker colored than Miami soils. Also included are some areas that have slopes of more than 12 percent or of less than 6 percent.

Fertility is medium, the available water capacity is high, and permeability is moderate. Runoff is medium to rapid. Erosion is a hazard if crops are grown.

This soil is suited to crops if protected against erosion. Corn, small grain, and hay are commonly grown. Because of the erosion hazard, hay and pasture commonly constitute half or more of the cropping system. Some slopes can be stripcropped. (Capability unit IIIe–5 (2.5a); woodland suitability group D)

Miami loam, 12 to 18 percent slopes (MoD).—This soil occurs within an undulating to steep landscape in the southeastern part of the county. The slopes range from fairly long to short, irregular, and complex. On the irregular slopes are many knobs and depressions. Associated with this soil are Morley, Conover, and Metamora soils.

Some areas of this soil are eroded and have a surface layer of dark yellowish-brown or dark-brown clay loam that is very low in organic-matter content and is sticky when wet and hard and crusty when dry. In most areas the limy underlying material is within 2 feet of the surface. In a few places the texture in the uppermost 2 feet is dominantly gravelly sandy loam. Included in mapping are spots of Morley soils, which are finer textured than Miami soils; spots of Conover soils, which are in waterways and depressions and are less well drained and darker colored than Miami soils; scattered areas of Owosso soils; and a few spots of sand.

Fertility is medium, and the available water capacity is high. Runoff is rapid, and the erosion hazard is serious if the soil is cultivated intensively.

Although this soil is suited to only limited use for crops, all of it has been cleared and cultivated. Long cropping systems are advisable. Grass-legume mixtures or similar protective vegetation are needed to check runoff and control erosion. (Capability unit IVe–1 (2.5a); woodland suitability group D)

Miami loam, 18 to 45 percent slopes (MoF).—This soil is within an undulating to steep landscape in the southeastern part of the county. The slopes are mainly short and fairly uniform, and the gradient is predominantly less than 25 percent.

The subsoil is thinner than that in the typical profile. The underlying material is at a depth of no more than 24 inches and in some places is just below the surface layer. Eroded areas have a surface layer of dark-brown clay loam that is low in organic-matter content and is sticky when wet and hard and crusty when dry. In places the surface layer consists of yellowish-brown gravelly sandy clay loam, and in others it consists of silt loam or silty clay and is underlain with silt and very fine sand.

This soil is not suitable for cultivation. Most areas are used for pasture. Hay is harvested where the slope is not too steep. Because of the erosion hazard, a permanent cover of grasses and legumes is needed. (Capability unit VIe–1 (2.5a); woodland suitability group D)

Montcalm Series

The Montcalm series consists of well drained and moderately well drained soils that occur on moraines, till plains, and outwash plains throughout the county.

In a typical profile, the surface layer consists of very dark grayish-brown loamy sand and is about 4 inches thick. The uppermost 10 inches of the subsoil is dark-brown over yellowish-brown, very friable loamy sand. At a depth of 14 inches is light yellowish-brown, loose sand, and at 26 inches, light-gray, loose sand stratified with yellowish-brown, friable loamy sand to sandy loam. The stratified layer extends to a depth of 48 inches and is underlain with 12 inches of yellowish-brown, friable loamy sand. The underlying material, at a depth of 60 inches, is light brownish-gray, mottled sand.

Fertility is low, the organic-matter content is low, the available water capacity is low, and permeability is moderately rapid. Runoff is slow to medium, depending on the slope. Crops usually show the effects of moisture deficiency late in the growing season. Water erosion and soil blowing are hazards.

Montcalm soils are used for crops, for pasture, and for woodland. The native vegetation is a mixture of hardwoods and conifers, including oak, aspen, white pine, hard maple, and some beech. There were once some dense stands of white pine.

Typical profile of Montcalm loamy sand, 2 to 6 percent slopes, undisturbed, located in the W½NE¼SE¼ sec. 32, T. 5 N., R. 14 W. (Zeeland Township):

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) loamy sand; very weak, fine, granular structure; very friable; neutral; abrupt, smooth boundary.

B21ir—4 to 8 inches, dark-brown (7.5YR 4/4) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B22ir—8 to 14 inches, yellowish-brown (10YR 5/8) loamy sand; weak, medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

A'2—14 to 26 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid; clear, wavy boundary.

A'2&B't—26 to 48 inches, light-gray (10YR 6/1) sand (A'2 part), and ⅛-inch to 1-inch bands of yellowish-brown (10YR 5/4 to 5/6) loamy sand to sandy loam, occurring every 3 or 4 inches (B't part); A'2 is single grain and loose; B't is massive and friable; slightly acid; clear, wavy boundary.

B'2t—48 to 60 inches, yellowish-brown (10YR 5/4) sandy loam; common, medium, faint, pale-brown (10YR 6/3) mottles; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

C—60 to 66 inches, light brownish-gray (10YR 6/2) loamy sand; many, coarse, distinct, yellowish-brown (10YR 5/8) mottles; weak, thin, platy structure; friable; medium acid.

In some places the profile includes a light-gray (10YR 6/1) or gray (10YR 5/1) A2 horizon that is 3 to 8 inches thick. In cultivated areas there is a dark-brown (10YR 4/3), dark yellowish-brown (10YR 4/4), or dark grayish-brown (10YR 4/2) Ap horizon.

The color of the A1 horizon ranges to very dark gray (10YR 3/1).

In the B1r horizon the color ranges to dark brown (10YR 4/4), reddish brown (5YR 4/4), or strong brown (7.5YR 5/6–5/8), and the texture is loamy sand or sand.

The color of the A'2 horizons ranges to light brownish gray (10YR 6/2), gray (10YR 6/1), or grayish brown (10YR 5/2). In some profiles the B't horizon is just below the uppermost A'2 horizon and A'2 material occurs as ped coatings and crack fillings in the B't horizon. The depth to the B't horizon ranges from 18 to 40 inches. The color of the B't horizon ranges to dark brown (7.5YR 5/6), reddish brown (5YR 4/7), or yellowish brown (10YR 5/8). The dominant texture is sandy loam.

In the A'2&B't horizon, the B't layers are ⅛ inch to 4 inches thick and the A'2 layers 2 to 12 inches thick.

The depth to the C horizon ranges from 48 to more than 66 inches.

Montcalm soils occur near Chelsea, Menominee, and Mancelona soils. Montcalm soils have a B'22t horizon, which Chelsea soils lack, and they have multiple B't horizons closer to the surface than Chelsea soils. Montcalm soils lack the finer textured IIB and IIC horizons that are characteristic of Menominee soils, and they lack the coarser textured IIC horizon that is characteristic of Mancelona soils.

Montcalm loamy sand, 0 to 2 percent slopes (MrA).—This soil is on moraines, till plains, and outwash plains.

In undisturbed wooded areas the surface layer is very dark gray or very dark grayish-brown loamy sand or light sandy loam and is 1 inch to 4 inches or more in thickness. Below it is a 3- to 8-inch layer of light-gray or gray loamy sand or sand. In some areas fine sand is the dominant texture throughout the profile. In other places the underlying material, at a depth of 42 to 66 inches, is limy clay loam; in some of these areas the upper part of the profile lacks the thin bands of loamy sand or sandy loam, and in some the subsoil is gravelly. In eroded places the surface layer is dark-brown loamy sand. Mottling occurs below a depth of 3 feet in some places. Included in mapping were spots of Rubicon soils, which have a sand texture, and of Chelsea soils, in which thin bands of loamy sand occur in the subsoil.

Fertility is low, the available water capacity is low, and runoff is slow. Crops are affected by moisture deficiency late in summer. Soil blowing is a hazard when the surface is exposed.

This soil is fairly well suited to crops. Most areas have been cleared and are cultivated. Corn, small grain, and hay are the common crops. Long cropping systems in which small grain and hay predominate are usual. This soil is also well suited to pine, and some areas have been reforested. Limitations for construction are few. (Capability unit IIIs–3 (4a); woodland suitability group C)

Montcalm loamy sand, 2 to 6 percent slopes (MrB).—This soil occurs on outwash plains, till plains, and moraines.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. The surface layer is 1 to 4 inches thick, and in places it has a sandy loam texture. Below the surface layer in a few areas is a 3- to 8-inch layer of light-gray or gray loamy sand or sand. In some areas fine sand is the dominant texture throughout the profile. In others, mainly in the uplands, the underlying material, at a depth of 48 to 66 inches, is limy clay loam; in some of these areas the upper part of the profile has a sandier texture than is typical, and in some the subsoil is gravelly. In eroded places the surface layer is dark-brown or dark yellowish-brown loamy sand or sand. In some of the eroded areas the sandy loam layer in the subsoil is within 2 feet of the surface. Mottling occurs below a depth of 3 feet in a few places. Included in mapping were spots of Rubicon soils and of Chelsea soils.

Fertility is low, the available water capacity is low, and runoff is slow. Crops are affected by a shortage of moisture late in summer. Water erosion and soil blowing are hazards if crops are grown.

This soil is fairly well suited to crops. Some of the acreage is cropland, some is pasture, some is woodland, and some is idle land. Corn, small grain, and hay are the common crops. Long cropping systems in which small grain and hay predominate are usual. This soil is also well suited to trees, and many areas have been reforested with pine. Limitations for construction are few. (Capability unit IIIs–4 (4a); woodland suitability group C)

Montcalm loamy sand, 6 to 12 percent slopes (MrC).—This soil occupies short, irregular slopes on moraines and long, narrow, uniform breaks on outwash plains. It is associated with the less sloping Montcalm soils.

The sandy loam layer in the subsoil generally is thinner and closer to the surface than the corresponding layer in the profile described. In some areas fine sand is the dominant texture throughout the profile. In other areas, mainly on uplands, the underlying material is at a depth of 36 to 60 inches and consists of limy clay loam; in some of these areas the upper part of the profile is sand, and in others the subsoil is gravelly. In eroded places the surface layer is dark yellowish-brown sand or loamy sand; in a few eroded places on knolls and short concave breaks, the sandy loam layer in the subsoil is exposed. Included in mapping were spots of Rubicon soils and of Chelsea soils.

Fertility is low, the available water capacity is low, and runoff is medium. Permeability is moderately rapid. Crops are affected by a shortage of moisture late in summer. Water erosion and soil blowing are hazards.

Some of this soil is cropland, some is pasture, and some is woodland. Row crops are grown occasionally, usually as part of a long cropping system that consists largely of hay and pasture. Some areas are idle, and some have been reforested with pine, either for timber or for Christmas trees. The slope constitutes a limitation for construction. (Capability unit IIIe–9 (4a); woodland suitability group C)

Morley Series

The Morley series consists of well drained and moderately well drained soils that occur in undulating to steep areas in the southeastern part of the county.

In a typical profile, the surface layer consists of dark-brown loam and is about 6 inches thick. The subsoil is about 20 inches thick. It is made up of 5 inches of light yellowish-brown, friable loam; 8 inches of yellowish-brown, firm heavy clay loam; and 7 inches of yellowish brown, mottled, firm clay loam. The underlying material, at a depth of 26 inches, is light brownish-gray, mottled, limy clay loam; it extends to a depth of several feet.

Fertility is high, the available water capacity is high, and permeability is moderately slow. Runoff is medium to rapid, depending on the slope. Erosion is a hazard.

Some areas of Morley soils are used for crops, but some are too steep to be suitable for cultivation. A few areas are still wooded. The native vegetation is a mixture of hardwoods, including sugar maple, beech, red oak, and largetooth aspen.

Typical profile of Morley loam, 2 to 6 percent slopes,

cultivated and eroded, located in the NE¼NW¼NW¼ NW¼ sec. 11, T. 5 N., R. 14 W. (Zeeland Township):

Ap—0 to 6 inches, dark-brown (10YR 3/3) loam; weak, medium, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

B21—6 to 11 inches, light yellowish-brown (10YR 6/4) clay loam; moderate, medium, subangular blocky structure; friable; contains a few very pale brown (10YR 7/3) remnants of an A2 horizon; strongly acid; clear, wavy boundary.

B22t—11 to 19 inches, yellowish-brown (10YR 5/4) heavy clay loam; weak, medium, subangular blocky structure; firm; peds have films of brown (10YR 5/3) clay; very strongly acid; gradual, wavy boundary.

B23—19 to 26 inches, yellowish-brown (10YR 5/4) clay loam; few, medium, distinct, light brownish-gray (10YR 6/2) mottles; moderate, medium, subangular blocky structure; firm; medium acid; clear, wavy boundary.

C—26 to 50 inches, light yellowish-brown (10YR 6/4) clay loam; common, medium, faint, light brownish-gray (10YR 6/2) mottles; moderate, medium, subangular blocky structure; firm; calcareous.

The solum is 20 to about 40 inches thick. The reaction of the B horizon ranges from very strongly acid to slightly acid.

In undisturbed areas the profile has an A1 and an A2 horizon instead of an Ap. The A1 horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2) and is 3 to 5 inches thick. The A2 horizon is very pale brown (10YR 7/3), pale brown (10YR 6/3), or grayish brown (10YR 5/2) and is 3 to 6 inches thick.

The texture of the B22t horizon is heavy silty clay loam, heavy clay loam, or light silty clay.

The texture of the C horizon is clay loam to silty clay loam.

Morley soils occur near Blount, Sims, and Owosso soils. Morley soils are better drained than Blount and Sims soils and have fewer gray mottles. They are finer textured in the upper part of the B2 horizon than Owosso soils. Morley soils and Nester soils formed in similar material, but Morley soils lack the A&B horizon that is characteristic of Nester soils.

Morley loam, 2 to 6 percent slopes (MtB).—This soil is on hillsides and hilltops within an undulating to steep landscape in the southeastern part of the county. Most areas are moderately well drained. Associated with this soil are Blount and Sims soils.

This Morley soil has the profile described as typical of the series. Small areas that are eroded have a surface layer of yellowish-brown clay loam that is sticky when wet and hard and crusty when dry. Included in mapping were spots of somewhat poorly drained Blount soils in minor depressions and drainageways, and spots of Owosso soils, which are sandy in the uppermost 2 to 3 feet. Also included were areas of nearly level, undisturbed soils that have a 5- to 10-inch surface layer of very dark gray loam.

Fertility is high, and the available water capacity is high. The organic-matter content is low. Runoff is medium, and permeability is moderately slow. The water table rises to within 3 or 4 feet of the surface during prolonged periods of wet weather and is often high at the planting season. Puddling and poor tilth result if the soil is worked when it is excessively wet. Erosion is a hazard in cultivated areas.

This soil is suited to crops, and most of it is cultivated. Corn, small grain, and hay are the common crops. Short cropping systems that include only a year or two of hay are usual. (Capability unit IIe–1 (1.5a); woodland suitability group B)

Morley loam, 6 to 12 percent slopes, eroded (MtC2).—This soil is on hillsides within an undulating to steep landscape in the southeastern part of the county. The slopes are short, and many are irregular. Most areas are well drained.

The surface in about half of the areas is yellowish-brown clay loam. In a few places that are severely eroded, the surface layer is heavy clay loam and the limy underlying material is within 15 inches of the surface. Generally the subsoil is free of mottling. Included in mapping were areas of Owosso soils, in which the underlying material is at a depth of about 2 feet and the upper part of the profile consists of dark-brown sandy loam. Also included were spots of somewhat poorly drained Blount soils in minor depressions and drainageways, and spots of soils that are sandy to a depth of 2 to 3 feet.

Fertility is high, the available water capacity is high, permeability is moderately slow, and runoff is rapid. The organic-matter content is low. Erosion is a problem if crops are grown.

Nearly all areas of this soil are cropland. Corn, small grain, and hay are the common crops. Moderately long cropping systems that include several years of small grain and hay are usual. (Capability unit IIIe–4 (1.5a); woodland suitability group B)

Morley loam, 18 to 25 percent slopes, eroded (MtE2).—This soil is on short, irregular slopes and slope breaks in the southeastern part of the county. It is well drained.

The surface layer is dark yellowish-brown clay loam. In places the limy underlying material is at the surface. Rills and shallow gullies are common.

Some of this soil has been cultivated in the past, but now most of it is idle or is covered with a mixture of grasses and legumes. Because of the slope, the very rapid runoff, and the effects of erosion, a permanent cover of vegetation is needed. (Capability unit VIe–1 (1.5a); woodland suitability group B)

Morley clay loam, 12 to 18 percent slopes, severely eroded (MuD3).—This soil is on slopes toward drainageways and on knolls and ridges. It is well drained. Some shallow gullies have formed.

The surface layer in about three-fourths of the areas is dark yellowish-brown clay loam. The limy underlying material is at a depth of about 15 inches in some places; in others the limy material is at the surface and rills are common. Included in mapping were areas of somewhat poorly drained Blount soils in drainageways and depressions, and spots of a soil that is sandy to a depth of 2 to 3 feet.

Because of the slope, the rapid runoff, and the effects of past erosion, this soil is not suited to crops. It needs a cover of hay or pasture plants or other permanent vegetation. (Capability unit VIe–1 (1.5a); woodland suitability group B)

Morley clay loam, 25 to 45 percent slopes, severely eroded (MuF3).—This soil occurs mainly on the side slopes of deep, V-shaped drainageways in the southeastern part of the county. The slopes are short and irregular.

The surface layer consists of yellowish-brown clay loam and is limy in many places. Rills and shallow gullies have formed in some areas, and seep spots occur in others. Included in mapping were some slopes of less than 25 percent.

Most areas of this soil are idle or are covered with grass, weeds, and brush. Because of the slope and the effects of erosion, a permanent cover of protective vegetation should be established and maintained. (Capability unit VIIe–1 (1.5a); woodland suitability group B)

Nester Series

The Nester series consists of well drained and moderately well drained soils that occur on uplands and along drainageways on lake plains. These soils developed in limy clay loam.

In a typical profile, the surface layer consists of dark grayish-brown loam and is about 7 inches thick. Below this is a 7-inch layer that consists of light brownish-gray, friable loam and brown, firm clay loam. The subsoil, about 14 inches thick, is reddish-brown, firm heavy clay loam. The underlying material, at a depth of about 28 inches, is brown, limy clay loam; it extends to a depth of at least 50 inches.

Fertility is high, the available water capacity is high, and permeability is moderately slow. Runoff is moderate to rapid, depending on the slope. Erosion is a hazard.

Some of the acreage is cropland, some is pasture, and some is woodland. Most of the gently sloping to strongly sloping areas are farmed intensively. Corn and small grain are the common crops. Some areas are still wooded. The native vegetation is a mixture of upland hardwoods, including sugar maple, beech, red oak, and largetooth aspen.

Typical profile of Nester loam, 2 to 6 percent slopes, cultivated and slightly eroded, located in the NE¼NW¼ SW¼ sec. 20, T. 8 N., R. 13 W. (Wright Township):

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loam; weak, fine, granular structure; friable; strongly acid; abrupt, smooth boundary.

A&B—7 to 14 inches, light brownish-gray (10YR 6/2) loam (A part) and brown (7.5YR 4/4) clay loam (B part); the A part is friable and has weak, fine, granular structure; the B part is firm and has weak, medium, subangular blocky structure; both parts are strongly acid; A material completely or partly surrounds peds and fills cracks, voids, and channels; abrupt, irregular boundary.

B22t—14 to 28 inches, reddish-brown (5YR 4/3) heavy clay loam; moderate, medium, angular blocky structure; firm; clay films on peds and in voids in lowermost 4 to 6 inches; slightly acid; clear, irregular boundary.

C—28 to 50 inches, brown (7.5YR 4/4) clay loam; weak, coarse, angular blocky structure; firm; pinkish-gray (5YR 6/2) lime coatings and streaks; calcareous.

In undisturbed areas the profile has an A1 horizon and an A2 horizon instead of an Ap. The A1 horizon is thin and consists of very dark brown (10YR 2/2) or very dark gray (10YR 3/1) loam, fine sandy loam, or sandy loam. The A2 horizon is 2 to 5 inches thick and consists of pale-brown (10YR 6/3), light-gray (10YR 7/2), grayish-brown (10YR 5/2), or light brownish-gray (10YR 6/2) loam, fine sandy loam, or sandy loam.

The Ap horizon is dark grayish brown (10YR 4/2), dark brown (10YR 4/3), or dark gray (10YR 4/1). In some cultivated areas the profile includes a thin A2 horizon between the Ap and the A&B horizons.

The texture of the B22t horizon is heavy clay loam, heavy silty clay loam, or light silty clay. In some places the B horizon is mottled below a depth of 24 inches.

The depth to the calcareous C horizon ranges from 24 to about 40 inches. The texture of this horizon is clay loam or silty clay loam.

Nester soils and Morley soils formed in similar material. Nester soils have an A&B horizon, which Morley soils lack. Nester soils occur near Ubly and Kawkawlin soils. They are finer textured than Ubly soils in the upper part of the solum, and they are better drained and less mottled than Kawkawlin soils.

Nester loam, 2 to 6 percent slopes (NeB).—This soil occurs on uplands in all parts of the county except the southeastern.

This soil has the profile described as typical of the series. In areas that have not been disturbed, the surface layer is very dark gray or very dark brown and is 3 to 5 inches thick. The subsurface layer in these areas is 2 to 5 inches thick and consists of pale-brown to light brownish-gray loam or sandy loam. An inch or two of the subsurface layer remains in some cultivated areas. In eroded places the surface layer is dark grayish-brown clay loam, and immediately below it is the subsoil of reddish-brown heavy clay loam. Where drainage is only moderately good, the lower part of the subsoil is mottled. In some areas, mainly in and around Eastmanville, the subsoil is silty clay and the underlying material is heavy clay loam or silty clay loam. Drainage in these areas is moderately good, and mottles occur in the lower part of the subsoil and in the underlying material. Where the uplands merge with the plains, the texture in the uppermost 3 feet is coarser than is typical, and in some of these areas, the underlying material consists of sand or loamy sand and is less limy than the underlying material in the typical profile.

Included in mapping were spots of Ubly soils, which consist of sandy loam to a depth of 18 to 40 inches, and spots of Kawkawlin and Sims soils, which occur in depressions and drainageways and are less well drained than Nester soils. Also included were areas in which the slope is less than 2 percent; in these areas drainage is moderately good and the lower part of the profile is mottled.

Fertility is high, the available water capacity is high, and permeability is moderate. The organic-matter content is low. Where the slope is more than 4 percent, runoff is medium and erosion is a hazard. The soil warms up and dries out slowly in spring, and it compacts and puddles readily if worked when wet. The included wet spots need to be drained artificially.

Most areas of this soil are farmed intensively, some are in grass-legume hay, and few are wooded. (Capability unit IIe–1 (1.5a); woodland suitability group B)

Nester loam, 6 to 12 percent slopes (NeC).—This soil is on uplands and on short slopes along drainageways that dissect lake plains.

In the areas on lake plains, the profile includes thin layers of silt and fine sand below a depth of 3 feet and one or two such layers at a lesser depth. In some areas in and around Eastmanville, the subsoil is silty clay and the underlying material is heavy clay loam or heavy silty clay loam. Where the uplands merge with the plains, the texture in the uppermost 3 feet is coarser than is typical and the underlying material consists of sand and gravel and is less limy than the underlying material in the typical profile. Many areas of this soil are eroded, and in these places the surface layer is dark grayish-brown clay loam. Drainage is good in most areas, but in depressions and on the lower part of slopes, it is only moderately good, and in such places the lower part of the subsoil is mottled. Included in mapping were spots of Ubly soils, which consist of sandy loam to a depth of 18 to 42 inches, and spots of Kawkawlin soils, which are in depressions and drainageways and are less well drained than Nester soils. Also included were some areas that have slopes of more than 12 percent or less than 6 percent.

Fertility is high, the available water capacity is high,

and permeability is moderately slow. The organic-matter content is low. Runoff is medium to rapid, depending on the ground cover. Erosion is a hazard if crops are grown.

Corn, small grain, and hay are the common crops. Because of the slope and the erosion hazard, a large proportion of grain and hay crops in the cropping system is usual. (Capability unit IIIe–4 (1.5a); woodland suitability group B)

Nester loam, 12 to 18 percent slopes (NeD).—This soil is on uplands and on short slopes along drainageways that dissect lake plains.

In the areas on lake plains, the profile includes thin layers of silt and fine sand. Where the uplands and plains merge, the underlying material is sand or loamy sand instead of clay loam. There are scattered areas in which a 2-foot layer of sandy loam overlies the clay loam substratum. In the many eroded areas, the surface layer is dark yellowish-brown clay loam, the subsoil is thinner than that in the typical profile, and the depth to the underlying material is less than 24 inches. Reddish-brown clay loam is at the surface in severely eroded spots. Included in mapping were spots of sandy loam and spots of less well drained Kawkawlin soils.

Fertility is high, the available water capacity is high, and permeability is moderately slow. Runoff is rapid. The organic-matter content is low, and tilth is generally poor.

Nearly all of this soil is used for crops or for pasture. Because of the erosion hazard, cropping systems should be long and cultivated crops should be grown only occasionally. Permanent vegetation affords protection against erosion. (Capability unit IVe–1 (1.5a); woodland suitability group B)

Nester loam, 18 to 25 percent slopes (NeE).—This soil occurs on the sides of deep, V-shaped drainageways, both on uplands and on lake plains, and also on other parts of the uplands.

In the areas on lake plains, the surface and subsurface layers have a silty texture. The surface in a few areas has a thin covering of sand or loamy sand. In eroded areas the surface layer is dark yellowish-brown or dark reddish-brown clay loam, and the subsoil is thinner and lighter colored than that in the typical profile. In these areas the depth to the limy underlying material is generally more than 24 inches. Included in mapping were small areas where the underlying material is heavy silty clay loam or light silty clay instead of clay loam and is at a depth of a foot or two. Also included were spots of Kawkawlin and Sims soils, both of which are more poorly drained than Nester soils.

Because of the slope and the erosion hazard, this soil is not suitable for cultivation. Permanent vegetation is needed for control of erosion and conservation of moisture. (Capability unit VIe–1 (1.5a); woodland suitability group B)

Nester loam, 25 to 45 percent slopes (NeF).—This soil occurs on the sides of deep, V-shaped drainageways on uplands and lake plains and on other short slopes on uplands. The areas are long and narrow and of small size, but the total acreage is large.

Many areas of this soil are eroded, and in these places the surface layer is yellowish-brown or reddish-brown clay loam or silty clay loam. The depth to the limy underlying material is less than in the typical profile. A few shallow gullies have formed in a few areas. The underlying material in a few areas is sandy loam, loamy sand, or sand. Included in mapping were spots of Kawkawlin, Sims, and Hettinger soils, all of which are less well drained than Nester soils.

Because of the slope and the erosion hazard, this soil is not suited to crops. Some areas have a cover of grasses and legumes, but even pasture use should be restricted. Most areas are idle or are growing up to trees and brush. Permanent vegetation is needed. (Capability unit VIIe–1 (1.5a); woodland suitability group B)

Nester clay loam, 6 to 12 percent slopes, severely eroded (NsC3).—This soil is on uplands and along drainageways on lake plains.

Erosion has removed the original surface layer, the subsurface layer, and in many places the upper part of the subsoil. In about half the areas, the present surface layer is reddish-brown heavy clay loam. In others it is dark grayish-brown clay loam. The limy underlying material is within 2 feet of the surface in many places, and in small areas it is at the surface. In a few places the underlying material is loamy sand or sand and is at a depth of 12 inches. In the areas on lake plains, the surface layer is silt loam or silty clay loam, and the subsurface layer consists of strata of limy silt, fine sand, and silty clay. Included in mapping were small spots that are less severely eroded.

This soil is very low in organic-matter content. It has poor structure and poor tilth and is very sticky when wet and hard and crusty when dry. Water is not absorbed readily, and most of it runs off.

All of this soil is now in cultivation or has been in the past. The effects of erosion make it difficult to establish a full stand of a crop. (Capability unit IVe–3 (1.5a); woodland suitability group B)

Nester clay loam, 12 to 18 percent slopes, severely eroded (NsD3).—This soil is on short slopes on uplands and along drainageways on lake plains.

Erosion has removed the original surface layer, the subsurface layer, and part of the subsoil. The color of the present surface layer is predominantly dark yellowish brown but in some places it is reddish brown. The limy underlying material is close to the surface in places. The underlying material in a few areas is nonlimy sand or loamy sand and is only about 12 inches below the surface. Along the drainageways on lake plains, the surface layer is silt loam or silty clay loam, and the subsurface layer consists of strata of silt, fine sand, and silty clay. Included in mapping were small areas that are less severely eroded.

This soil is very low in organic-matter content. It has poor structure and poor tilth and is sticky when wet and hard and crusty when dry. Water is not absorbed readily, and much of it runs off.

Some of this soil has been cultivated in the past. The effects of erosion make it difficult to establish a full stand of a crop. Forage crops can be grown under careful management. Permanent vegetation is needed. (Capability unit VIe–1 (1.5a); woodland suitability group B)

Nester clay loam, 18 to 25 percent slopes, severely eroded (NsE3).—This soil is on the sides of deep, V-shaped drainageways, both on uplands and on lake plains, and also on other upland slopes.

The surface layer consists of yellowish-brown clay loam or silty clay loam. In places limy clay loam or silty clay loam is at the surface.

Because of the slope and the hazard of erosion, this soil should not be farmed. Most areas have been cultivated in the past, but now some of these areas are idle, some are growing up to weeds and brush, and some are used for pasture. Permanent vegetation is needed. (Capability unit VIIe-1 (1.5a); woodland suitability group B)

Nester clay loam, 25 to 45 percent slopes, severely eroded (NsF3).—This soil occurs on the sides of deep, V-shaped drainageways, both on uplands and on lake plains, and also on other short upland slopes.

Erosion has removed the original surface layer, subsurface layer, and subsoil. The present surface layer is reddish-brown heavy clay loam or dark grayish-brown clay loam. The limy underlying material is within 20 inches of the surface and in many places is exposed. Rills are common, and some shallow gullies have developed. In protected spots that are less severely eroded, the surface layer is loam, but even in these places the profile is thin. There are some areas in which the underlying material consists of sand or loamy sand and is just below the surface layer. Included in mapping were spots of somewhat poorly drained Kawkawlin soils and poorly drained Sims soils.

Because of the slope and the erosion hazard, this soil is not suited to crops. Some areas were once cultivated, but these areas are now idle or are covered with brush or grass. A permanent cover of protective vegetation is needed. (Capability unit VIIe–1 (1.5a); woodland suitability group B)

Newaygo Series

The Newaygo series consists of well-drained soils that occur on outwash plains, terraces, and deltas. These soils are underlain with limy sand and gravel at a depth of 24 to 40 inches.

In a typical profile, the surface layer consists of dark reddish-brown sandy loam and is about 8 inches thick. The subsoil is about 32 inches thick. The upper 22 inches is reddish-brown, very friable light sandy loam, and the lower 10 inches is reddish-brown, firm light clay loam. The underlying material, at a depth of 40 inches, is pale-brown, limy sand and gravel that extends to a depth of several feet.

Fertility is medium, and the available water capacity is moderate. Crops show the effects of a moisture shortage during the latter part of the growing season in dry years. Runoff is slow. Permeability is moderate to a depth of 24 to 40 inches and very rapid in the underlying material. Erosion and soil blowing are hazards.

Newaygo soils are used for crops, for pasture, and for woodland. Corn, small grain, and hay are the common crops. Very few areas are wooded. The native vegetation is a mixture of hardwoods and conifers, including hard maple, beech, oak, hickory, and white pine.

Typical profile of Newaygo sandy loam, cultivated and eroded, located in the NE¼NW¼NE¼SE¼ sec. 12, T. 7 N., R. 14 W. (Allendale Township):

Ap—0 to 8 inches, dark reddish-brown (5YR 3/3) sandy loam; weak, fine, granular structure; very friable; medium acid; abrupt, smooth boundary.

Bir—8 to 30 inches, reddish-brown (5YR 4/4) light sandy loam; weak, fine, subangular blocky structure; very friable; strongly acid; clear, irregular boundary.

B't—30 to 40 inches, reddish-brown (5YR 4/3) light clay loam; moderate, medium, subangular blocky structure; firm; neutral; abrupt, irregular boundary.

IIC—40 to 66 inches, pale-brown (10YR 6/3) sand and gravel; single grain; loose; calcareous.

In undisturbed areas the profile has an A1 and an A2 horizon instead of an Ap. The A1 horizon is very dark grayish brown (10YR 3/2) or very dark gray (10YR 3/1) and is 2 to 4 inches thick. The A2 is gray (10YR 5/1) or light brownish gray (10YR 6/2) and is 2 to 6 inches thick. The A2 horizon is strongly acid to slightly acid.

In uneroded areas the color of the Ap horizon ranges to very dark brown (10YR 3/2), dark grayish brown (10YR 4/2), or very dark gray (10YR 3/1).

In the Bir horizon the color ranges to dark brown (7.5YR 4/4) or reddish brown (5YR 4/3), and the texture is sandy loam or loamy sand. The reaction of this horizon ranges from strongly acid to slightly acid. In some profiles a pale-brown (10YR 6/3), slightly acid to mildly alkaline A'2 horizon, 1 to 3 inches thick, occurs above the B't horizon; in other profiles A'2 material occurs only as thin coatings on peds in the upper part of the B't horizon. The texture of the B't horizon is heavy sandy loam, sandy clay loam, or light clay loam. In some places this horizon is gravelly. In reaction it ranges from slightly acid to mildly alkaline.

Newaygo soils occur near Mancelona and Montcalm soils. Newaygo soils have a thicker B't horizon than Mancelona soils. They have a finer textured B't horizon than Montcalm soils, and they have a IIC horizon of sand and gravel, which Montcalm soils lack. Newaygo soils formed in the same kind of material as Fox soils, which lack a Bir horizon.

Newaygo sandy loam, 0 to 6 percent slopes (NwB).—This soil occurs on outwash plains, terraces, and deltas. Associated with it are Mancelona, Matherton, Gladwin, and Lacota soils.

In some places the color of the upper part of the profile is less red than in the typical profile. In other places the soil is less eroded and the surface layer is darker colored. A gray or light brownish-gray subsurface layer occurs in some areas. Included in mapping were spots of Mancelona soils, which are coarser textured than Newaygo soils, and of Gladwin, Matherton, and Lacota soils, which are less well drained.

Fertility is medium, and the available water capacity is moderate. The moisture supply is usually deficient in the latter part of the growing season.

This soil is suited to crops if well managed. Cropping systems usually consist largely of small grain and hay. A few areas are sources of sand and gravel. (Capability unit IIs–2 (3a); woodland suitability group A)

Oshtemo Series

The Oshtemo series consists of well-drained soils that occur on outwash plains and on rolling to hilly moraines in the eastern and southeastern parts of the county. These soils developed in 40 to 66 inches of sandy loam or loamy sand underlain with sand and gravel.

In a typical profile, the surface layer consists of dark-brown light sandy loam and is about 10 inches thick. Below this is a 10-inch subsurface layer of pale-brown loamy sand. The subsoil is about 30 inches thick. It is made up of 16 inches of strong-brown, very friable loamy sand; 9 inches of strong-brown, friable light sandy clay loam; and 5 inches of reddish-yellow, very friable light sandy loam. The underlying material, at a depth of 50 inches, is yellow coarse sand; it extends to a depth of at least 66 inches.

Fertility is low, the available water capacity is low, and permeability is moderate. Crops show the effects of a moisture shortage during prolonged periods of dry weather.

The organic-matter content is low. Runoff is slow to rapid, depending on the slope.

Some of the acreage is cropland, some is woodland, and some is pasture. Corn, small grain, and hay are the common crops. The native vegetation is a mixture of hardwoods, including oak, hickory, and maple. A few areas are sources of sand and gravel. Limitations for construction are few.

Typical profile of Oshtemo sandy loam, 0 to 2 percent slopes, cultivated, located in the W½SW¼SE¼SE¼ sec. 18, T. 7 N., R. 13 W. (Tallmadge Township):

Ap—0 to 10 inches, dark-brown (10YR 3/3) light sandy loam; moderate, medium, granular structure; friable; extremely acid; abrupt, smooth boundary.

A2—10 to 20 inches, pale-brown (10YR 6/3) loamy sand; structureless (single grain); loose; strongly acid; clear, wavy boundary.

B1—20 to 36 inches, strong-brown (7.5YR 5/8) loamy sand; structureless (single grain); very friable; very strongly acid; clear, wavy boundary.

B2t—36 to 45 inches, strong-brown (7.5YR 5/6) light sandy clay loam; weak, fine, subangular blocky structure; friable; very strongly acid; clear, wavy boundary.

B3—45 to 50 inches, reddish-yellow (5YR 7/8) light sandy loam; weak, coarse, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

IIC—50 to 66 inches, yellow (10YR 8/8) coarse sand; structureless (single grain); loose; strongly acid.

The solum is 40 inches to more than 60 inches thick. The reaction of the solum below the Ap horizon ranges from medium acid to very strongly acid.

The texture of the Ap horizon is sandy loam or loamy sand. The color ranges to very dark grayish brown (10YR 3/2) or brown (10YR 5/3). The dry color is light grayish brown (10YR 6/2). The reaction of this horizon ranges from neutral to extremely acid, depending upon how much lime has been applied. The color of the A2 horizon ranges to brown (10YR 5/3) or yellowish brown (10YR 5/4).

In both the B1 and the B3 horizons, the texture is either sandy loam or loamy sand. The B2t horizon is at a depth of 12 to more than 36 inches and is less than 10 inches thick. The texture of this horizon is sandy loam, light sandy clay loam, or clay loam. The color of the B3 horizon ranges to reddish brown (5YR 4/4) or dark yellowish brown (10YR 4/4). Below a depth of 40 inches in some profiles, discontinuous layers of dark-brown (7.5YR 3/2) loamy sand or sandy loam, ⅛ inch to 2 inches thick, alternate with 4- to 12-inch layers of B3 material.

The reaction of the C horizon ranges from very strongly acid to mildly alkaline. In some profiles the C horizon is as much as 15 percent gravel.

Oshtemo soils occur near Spinks, Matherton, and Wasepi soils. Oshtemo soils are more acid than Spinks soils and have a IIC horizon of coarse sand that Spinks soils lack. They are better drained than Matherton and Wasepi soils. They formed in the same kind of material as Mancelona soils but lack the Bir horizon that is characteristic of Mancelona soils.

Oshtemo sandy loam, 0 to 2 percent slopes (OsA).—This soil occurs on outwash plains in the eastern part of the county and on hilltops within rolling to hilly uplands in the southeastern part of the county.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. In cultivated areas the plow layer is dominantly dark brown or very dark brown sandy loam or, in a few areas, loamy sand. In undisturbed areas the surface layer is darker colored. Eroded spots in some cultivated areas have a lighter colored surface layer of loamy sand. In other places the reaction is less acid than is typical, and the underlying material is limy and is within 40 inches of the surface. Included in mapping were spots of Hillsdale soils, which have a thicker and finer textured subsoil than Oshtemo soils. Also included were some areas that have slopes of more than 2 percent.

Fertility is low, the organic-matter content is low, and the available water capacity is low. The soil is droughty in summer, and it is readily susceptible to soil blowing.

Some of this soil has been cleared and is cultivated, some is in hay, and some is wooded. Corn, small grain, and hay are the common crops. Long cropping systems in which small grain and hay predominate are suitable. Limitations for construction are few. Some areas have been subdivided, and other areas are awaiting such use. (Capability unit IIIs–3 (4a); woodland suitability group M)

Oshtemo sandy loam, 2 to 6 percent slopes (OsB).—This soil occurs on outwash plains in the eastern part of the county and on rolling to hilly moraines in the southeastern part of the county.

Where this soil is eroded, the plow layer is dark grayish-brown sandy loam or loamy sand and the underlying material is within 3 feet of the surface. In some areas in Jamestown Township, the soil is finer textured than is typical and the finest textured part of the subsoil, a layer at least 10 inches thick, is gravelly clay loam. Included in mapping were severely eroded spots in which the surface layer is dark-brown sandy clay loam; spots in which the reaction is less acid than is typical and the underlying material is limy and is within 40 inches of the surface; and a few small areas in which the slope is more than 6 percent. Also included were spots of Hillsdale soils, which consist dominantly of sandy loam throughout the profile.

Fertility is low, the organic-matter content is low, and the available water capacity is low. The soil is droughty in summer, and it is readily susceptible to both water erosion and soil blowing.

Some of this soil has been cleared and is cultivated, some is in hay, and a little is wooded. Corn, small grain, and hay are the common crops. Long cropping systems in which small grain and hay predominate are suitable. Limitations for construction are few. Some areas have been subdivided, and others are awaiting such use. A few areas are sources of sand and gravel. (Capability unit IIIs–4 (4a); woodland suitability group M)

Oshtemo sandy loam, 6 to 12 percent slopes (OsC).—Some of this soil occupies long, narrow, smooth slopes on outwash plains in the eastern part of the county, and some occupies irregular hillsides and hilltops on moraines in the southeastern part.

Where this soil is eroded, the plow layer is strong-brown sandy loam or clay loam and the yellow substratum is much closer to the surface than in uneroded places. The subsurface layer is thinner than that in the typical profile and consists of sandy loam rather than loamy sand. The subsoil also is thinner than is typical, and the depth to the underlying material is less. In some areas the upper part of the profile is finer textured, and the finest textured part of the subsoil, a layer at least 10 inches thick, is clay loam. Included in mapping were spots in which the underlying material is limy and is within 40 inches of the surface, and also areas in which thin bands of finer textured soil material occur throughout the profile.

Fertility is low, and the available water capacity is low. In eroded areas the surface layer has poor tilth and is sticky when wet and hard and crusty when dry. Water is

not absorbed readily. The soil is readily susceptible to both water erosion and soil blowing.

Some of this soil has been cleared and cultivated. Corn, small grain, and hay are the common crops. Cropping systems in which small grain and hay predominate are suitable. A few areas are used only for forage crops. The slope is a limitation for construction. (Capability unit IIIe–9 (4a); woodland suitability group M)

Oshtemo sandy loam, 12 to 18 percent slopes (OsD).—Some of this soil occupies long, narrow, smooth slopes on outwash plains in the eastern part of the county, and some occupies hillsides and hilltops on moraines in the southeastern part.

In most areas the surface layer is strong-brown sandy loam or loamy sand. Both the surface layer and the subsoil are thinner than those in the typical profile, and the yellow underlying material is within 36 inches of the surface in most places. Where erosion has been severe enough to remove the surface layer, the subsurface layer, and the upper part of the subsoil, the underlying material is within 2 feet of the surface. In some areas the upper part of the profile is finer textured than is typical, and the finest textured part of the subsoil, a layer at least 10 inches thick, is clay loam. The underlying material in some eroded spots is limy and is within 2 feet of the surface. In some eroded spots the surface layer is brown clay loam, and the underlying material is limy and is within 2 feet of the surface. Included in mapping were severely eroded spots in which the original underlying material is at the surface, and also spots in which the underlying material includes thin bands of finer textured soil material.

Fertility is low, and the available water capacity is low. The organic-matter content is very low, and tilth is poor. The surface layer is sticky when wet and hard and crusty when dry. Runoff is rapid, and little water is absorbed. Water erosion is a serious hazard.

All of this soil has been cleared, and all of it is or has been cultivated. Corn, small grain, and hay are the common crops. Because of the slope and the erosion hazard, a permanent cover of grass or of a grass-legume mixture is more suitable than cultivated crops. (Capability unit IVe–9 (4a); woodland suitability group M)

Owosso Series

The Owosso series consists of well drained and moderately well drained soils that occur on uplands in the southern part of the county. These soils developed in 18 to 40 inches of sandy loam or loamy fine sand over limy clay loam and silty clay loam.

In a typical profile, the surface layer consists of dark grayish-brown sandy loam and is about 7 inches thick. Below it is a 5-inch subsurface layer of brown loamy fine sand. The subsoil is about 18 inches thick. It is made up of 7 inches of yellowish-brown, friable sandy loam; 6 inches of dark yellowish-brown, friable heavy sandy loam; and 5 inches of yellowish-brown, mottled, friable sandy clay loam. The underlying material, at a depth of about 30 inches, is brown, mottled clay loam; it extends to a depth of at least 60 inches.

Fertility is medium, the organic-matter content is moderately low, the available water capacity is moderate, and runoff is medium. Permeability is moderately rapid in the upper part of the profile and moderate in the lower part. Crops show the effects of a moisture shortage late in the growing season.

Owosso soils are well suited to most crops. Some of the acreage is cropland, some is pasture, and some is woodland.

Typical profile of Owosso sandy loam, cultivated, located in the E½SE¼SE¼SW¼ sec. 27, T. 5 N., R. 13 W. (Jamestown Township):

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, medium, granular structure; friable; neutral; abrupt, smooth boundary.

A2—7 to 12 inches, brown (10YR 5/3) loamy fine sand; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B1—12 to 19 inches, yellowish-brown (10YR 5/4) sandy loam; weak, medium, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.

B21t—19 to 25 inches, dark yellowish-brown (10YR 4/4) heavy sandy loam; moderate, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

IIB22t—25 to 30 inches, yellowish-brown (10YR 5/4) sandy clay loam; common, medium, faint, light yellowish-brown (10YR 6/4) mottles; weak, coarse, subangular blocky structure; friable to firm; neutral; gradual, wavy boundary.

IIC—30 to 60 inches, brown (10YR 5/3) clay loam; common, medium, faint, yellowish-brown (10YR 5/4) mottles; weak, medium, angular blocky structure; firm; moderately alkaline.

The solum is 24 to 44 inches thick. In reaction it ranges from strongly acid to neutral. In places the lower part of the solum contains a considerable amount of gravel.

In undisturbed areas there is a 2- to 4-inch, very dark gray (10YR 3/1) A1 horizon.

The color of the Ap horizon ranges to dark brown (10YR 4/3) or dark gray (10YR 4/1), and that of the A2 to yellowish brown (10YR 5/4). The structure of the A2 horizon in some profiles is weak, medium, platy.

In the B1 horizon the color ranges to brown (10YR 5/3), dark yellowish brown (10YR 4/4), or brown (7.5YR 4/4), and the texture is loamy fine sand, heavy loamy sand, or sandy loam. The color of the IIB22t ranges to brown (7.5YR 4/4), and the texture is sandy clay loam, sandy clay, or clay loam. In some places the IIB22t horizon is free of mottles.

The texture of the IIC horizon is clay loam or silty clay loam. In some places this horizon is free of mottles.

Owosso soils occur near Miami and Morley soils. They are coarser textured in the upper part of the B horizon than either Miami or Morley soils. Owosso soils are similar to Menominee and Ubly soils but lack the Bir horizon that is characteristic of both of these soils.

Owosso sandy loam, 2 to 6 percent slopes (OwB).—This soil is on hilltops and hillsides in the rolling uplands of the southeastern part of the county. Morley, Blount, and Miami soils are common in these areas.

In some areas of this soil, the dominant texture in the uppermost 18 to 40 inches of the profile is loamy sand. In other places this part of the profile is gravelly and has a thin layer of sand or gravel below the middle layer of the subsoil and above the substratum. Some of these areas are less well drained than is typical. Where the soil is eroded, the underlying material is within 24 inches of the surface and the surface layer consists of yellowish-brown sandy loam or gravelly sandy loam that is very low in organic-matter content. Included in mapping were spots of Morley and Miami soils, which are loamy in the upper part of the profile. Also included were areas of Metamora and Blount soils, which are in depressions and drainageways and are less well drained than Owosso soils.

Fertility is medium, and the available water capacity is moderate. Permeability is moderately rapid in the upper

part of the profile and moderate in the lower part. In dry years crops show the effects of a moisture shortage late in summer. Water erosion and soil blowing are hazards.

This soil is well suited to most crops, and most of it is cropland. A few areas are in pasture, and a few are still wooded. (Capability unit IIe–3 (3/2a); woodland suitability group A)

Pinconning Series

The Pinconning series consists of poorly drained, level to depressional soils that occur on lake plains. These soils developed in 18 to 40 inches of sandy material over limy silty clay.

In a typical profile, the surface layer consists of black sandy loam and is about 8 inches thick. Directly below this is the underlying material, which is made up of 4 inches of dark-gray, mottled, very friable loamy sand; 24 inches of light brownish-gray, mottled, loose sand; and at least 14 inches of gray, mottled, limy silty clay.

Fertility is low, the available water capacity is moderate, and runoff is very slow to ponded. Permeability is moderately rapid in the upper part of the profile and slow in the silty clay layer. The water table is near the surface much of the year unless lowered by artificial drainage. If the water table is lowered too much, the soils are droughty during the growing season. When dry, the soils blow readily. Frost damage to crops is another hazard.

Some areas of these soils have been cleared and drained and are cultivated; some are idle; some are used for hay and pasture. There are some second-growth woodlots. The native vegetation consists mainly of lowland hardwoods, including elm, red maple, silver maple, and ash; it also contains some white pine. The trees are generally slow growing, shallow rooted, and of poor quality.

Typical profile of Pinconning sandy loam, cultivated, located in the NE¼NE¼SW¼ sec. 36, T. 6 N., R. 15 W. (Olive Township):

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; weak, medium, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

C1g—8 to 12 inches, dark-gray (10YR 4/1) loamy sand; few, fine, faint, very dark gray (10YR 3/1) mottles and few, fine, faint, dark grayish-brown (10YR 4/2) mottles; weak, medium, subangular blocky structure; very friable; neutral; clear, wavy boundary.

C2—12 to 36 inches, light brownish-gray (10YR 6/2) sand; common, medium, distinct, light-gray (10YR 7/2) mottles and few, fine, faint, gray (10YR 6/1) mottles; single grain; loose; neutral; abrupt, smooth boundary.

IIC3g—36 to 50 inches, gray (N 5/0) silty clay; many, coarse, prominent, dark yellowish-brown (10YR 4/4) mottles; massive; plastic when wet; calcareous.

The depth to the IIC3g horizon ranges from 18 to 40 inches but is dominantly more than 24 inches. In some places a thin layer of black (10YR 2/1) organic material covers the surface.

The color of the Ap horizon (or, in undisturbed areas, the A1 horizon) ranges to very dark gray (10YR 3/1), and the texture is sandy loam, fine sandy loam, loamy fine sand, or loamy sand.

In the C1g and C2 horizons, the color ranges to gray (10YR 6/1–7/1) or grayish brown (10YR 5/2). The mottles in these horizons are faint to prominent.

The upper part of the IIC3g horizon is noncalcareous in some places.

Pinconning soils are similar to and occur near Breckenridge and Brevort soils. Pinconning soils are coarser textured in the uppermost 18 to 40 inches than Breckenridge soils. They have a finer textured IIC horizon than either Breckenridge or Brevort soils.

Pinconning loamy sand (0 to 2 percent slopes) (Pn).—This nearly level to depressional soil is on lake plains. Associated with it are Selkirk, Hettinger, and Iosco soils.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. In some areas the texture in the uppermost 18 to 40 inches of the profile is sandy loam or fine sandy loam. Included in mapping were some slopes between 2 and 4 percent. Also included were spots of Brevort soils, in which the underlying material is heavy clay loam or silty clay loam; spots of Allendale soils, which are better drained than Pinconning soils; and spots in which silty clay is just below the surface.

Fertility is low, and the available water capacity is moderate. The water table is high unless lowered artificially. The soil blows readily when dry and bare. Frost damage to crops is a hazard.

If drained, this soil is suitable for most crops. Some areas have been cleared and drained and are cultivated. Corn, small grain, and hay are the common crops. Long cropping systems that consist largely of hay and pasture are usual. Many of the areas once cultivated are now idle or are used for hay or pasture. Undrained areas are in pasture or woods. (Capability unit IIIw–8 (4/1c); woodland suitability group W)

Pinconning and Breckenridge sandy loams (0 to 2 percent slopes) (Pr).—The soils in this undifferentiated unit occur in the western part of the county, on lake plains and where the plains merge with the uplands. None of the areas mapped contains both soils. Most areas consist predominantly of Pinconning sandy loam, and the rest predominantly of Breckenridge sandy loam. Both soils are level to depressional, and both are poorly drained. Pinconning soils developed in loamy sand and sand over silty clay, and Breckenridge soils, which occur where the plains grade to the uplands, developed in sandy loam over clay loam.

Included in the areas dominated by Pinconning sandy loam are spots of Granby soils, which lack the silty clay substratum within 40 inches of the surface; spots of Au Gres and Allendale soils, which have slopes of 2 to 4 percent and are less poorly drained; and spots in which either the subsoil is cemented or chunks of cemented material occur below a depth of 12 inches. The areas that are dominantly Breckenridge sandy loam include spots of Brevort soils and spots of Iosco and Belding soils, which have slopes of 2 to 4 percent and are less poorly drained.

The Pinconning soil is low in fertility, and the Breckenridge soil is medium. Both have a moderate available water capacity. The water table is near the surface much of the year. When the water table recedes, permeability is moderate or moderately rapid in the uper part of both soils and moderately slow or slow in the underlying material. Both soils are suspectible to blowing. Frost damage to crops is a hazard.

If drained, these soils are suited to most of the common crops. Most areas have been cleared and cultivated, but now some are idle or are used only for hay or pasture. A few are covered with brush. (Capability unit IIIw–8 (Pinconning—4/1c, Breckenridge—3/2c); woodland suitability group W).

Richter Series

The Richter series consists of somewhat poorly drained soils that occur in glacial drainageways and on lake plains and outwash plains, mainly in the eastern half of the county. These soils developed in layers of sandy loam, fine sandy loam, loamy fine sand, and loamy sand.

In a typical profile, the surface layer consists of very dark grayish-brown sandy loam and is about 7 inches thick. Below this is a 3-inch subsurface layer of grayish-brown loamy sand. The subsoil is about 20 inches thick. It is made up of 4 inches of dark-brown, mottled, very friable loamy sand; 6 inches of dark yellowish-brown, mottled, friable sandy loam; 6 inches of brown, mottled, very friable loamy fine sand; and 4 inches of yellowish-brown, mottled, friable fine sandy loam. The underlying material, at a depth of 30 inches, consists of grayish-brown, mottled fine sandy loam.

Fertility is medium, and the available water capacity is moderate. Runoff is slow to medium, and water ponds in small depressions in spring. The water table is high in spring but recedes in summer. The organic-matter content is medium. When dry, the soils are susceptible to water erosion and soil blowing.

If drained artificially, these soils are suited to most crops. Corn, small grain, and hay are the common crops. Some areas are used for hay or pasture, and others are still wooded. The native vegetation is a mixture of hardwoods and conifers, including maple, elm, birch, aspen, and white pine.

Typical profile of Richter sandy loam, 0 to 2 percent slopes, cultivated, located in the SE¼NE¼SE¼ sec. 27, T. 6 N., R. 13 W. (Georgetown Township):

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

A2—7 to 10 inches, grayish-brown (10YR 5/2) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B21ir—10 to 14 inches, dark-brown (7.5YR 4/4) loamy sand; few, fine, prominent, red (2.5YR 4/8) mottles; weak, coarse, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B22ir—14 to 20 inches, dark yellowish-brown (10YR 4/4) sandy loam; many, medium, distinct, yellowish-red (5YR 5/8) mottles; moderate, medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

IIA'2—20 to 26 inches, brown (10YR 5/3) loamy fine sand; many, medium, faint, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

IIB't—26 to 30 inches, yellowish-brown (10YR 5/4) fine sandy loam; many, medium, distinct, strong-brown (7.5YR 5/8) mottles; moderate, medium, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

IICg—30 to 50 inches, grayish-brown (10YR 5/2), stratified fine sandy loam and loamy fine sand, common, medium, distinct, brownish-yellow (10YR 6/8) mottles; weak, medium, subangular blocky structure; friable; mildly alkaline.

The solum ranges from 24 inches to more than 42 inches in thickness. In reaction it ranges from medium acid to neutral. The thickness and texture of the horizons vary considerably. The thickness is predominantly between 1 and 6 inches. Loamy sand and sandy loam are the predominant textures, but others are represented. Gravel is scattered through some profiles.

In undisturbed areas there is an A1 horizon that is 1 to 5 inches thick. The range in color in this horizon is from black (10YR 2/1) to very dark grayish brown (10YR 3/2). In some places the profile includes a thin layer of black organic material.

The color of the Ap horizon ranges to dark brown (10YR 4/3) or dark grayish brown (10YR 4/2), and the texture is sandy loam, loamy sand, or loam. The color of the A2 horizon ranges to light brownish gray (10YR 6/2) or pale brown (10YR 6/3), and the texture is loamy sand, sand, or sandy loam.

In the B21ir and B22ir horizons, the color ranges to reddish brown (5YR 4/4), and the mottles are faint to prominent. The texture of these horizons is predominantly loamy sand or sandy loam, but thin strata of fine sandy loam, loam, and silt loam occur in some profiles.

The texture of the IIA'2 horizon is loamy sand, loamy fine sand, or sand. Scattered lenses of fine sandy loam or silty material occur in this horizon, mainly where the horizon is thickest.

In the IIB't horizon the color ranges to dark yellowish brown (10YR 4/4) or strong brown (7.5YR 5/8), and the texture is sandy loam, fine sandy loam, or silt loam.

The IICg horizon is predominantly mildly alkaline in reaction but ranges from neutral to moderately alkaline and is calcareous in some places. In some profiles strata of fine sand or gravel or both occur below a depth of 50 inches.

Richter soils formed in material similar to that in which Tonkey soils formed, but they are neither so wet nor so gray as Tonkey soils. Richter soils occur near Montcalm and Gladwin soils. They are less well drained than Montcalm soils, and they lack the sandy and gravelly IIC horizon that is characteristic of Gladwin soils.

Richter sandy loam, 0 to 2 percent slopes (RcA).—This soil occurs on outwash plains and lake plains and in glacial drainageways.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. In some places the dominant texture of the profile is loamy sand, in others it is loamy fine sand, and in still others it is fine sand. In protected depressions the surface is covered with a thin overwash of material washed from the surrounding slopes. Included in mapping were spots of poorly drained Tonkey soils in depressions and narrow drainageways; of Gladwin soils, which have gravelly underlying material; of Montcalm soils, which are better drained than Richter soils; and of Kibbie soils, which are a little finer textured. Also included are sandy spots; areas of a soil that has finer textured underlying material at a depth of 4 or 5 feet; and ridges, knolls, and depressions that have slopes of more than 2 percent.

Fertility is medium, and the available water capacity is moderate. The water table is high in spring but recedes in summer. Crops are likely to show the effects of a moisture shortage late in the growing season. When dry and bare, the soil is susceptible to blowing.

Most areas of this soil have been cleared and cultivated. Corn, small grain, and hay are the common crops. Some areas are used only for hay and pasture, and a few are still wooded. Trees grow slowly and are shallow rooted. (Capability unit IIw-6 (3b); woodland suitability group G)

Richter sandy loam, 2 to 6 percent slopes (RcB).—This soil occurs on outwash plains and lake plains and in glacial drainageways. Slopes are generally long, but short, irregular slopes occur on knolls and in depressions.

In some places the texture throughout the profile is sandy loam, and the strata of other textures are lacking. In other areas the dominant texture is fine sand, loamy sand, or sand. In eroded places the surface layer is dark grayish-brown or dark-brown sandy loam. Included in map-

ping were spots of poorly drained Tonkey soils in depressions and narrow drainageways; of Gladwin soils, which have gravelly underlying material; and of Montcalm soils, which are better drained. Also included are areas of soils that have fine-textured underlying material at a depth of 4 or 5 feet and areas in which the slope is more than 6 percent or less than 2 percent.

Fertility is medium, and the available water capacity is moderate. The water table is within 2 feet of the surface after prolonged periods of wet weather. In summer it recedes, and the soil becomes droughty late in the growing season. The soil is susceptible to water erosion and blowing when unprotected.

Most of the acreage is used for crops or pasture. Cropping systems consist largely of small grain and hay. Only a few areas are wooded. Trees grow slowly and are shallow rooted. (Capability unit IIw-7 (3b); woodland suitability group G)

Rubicon Series

This series consists of well-drained soils that occur on outwash plains and lake plains, on stabilized dunes, and, less extensively, on uplands. These soils developed in deep deposits of acid sand.

In a typical profile, the surface layer consists of very dark gray sand and is about 3 inches thick. Below this is a 6-inch subsurface layer of light brownish-gray sand. The subsoil is about 17 inches thick. It is made up of dark-brown, strong-brown, and yellowish-brown, loose sand. The underlying material, at a depth of about 26 inches, is very pale brown sand.

Fertility is very low, the available water capacity is very low, and permeability is rapid. Runoff is slow to medium, depending on the slope. Soil blowing is a hazard if the surface is exposed.

These soils are not suitable for farm crops. They are suitable for trees, for wildlife habitat, and for recreational facilities. Much of the acreage is idle, is in forest, or is reforesting. The native vegetation is a mixture of hardwoods and conifers, including white pine, white oak, black oak, and aspen.

Typical profile of Rubicon sand, 0 to 6 percent slopes, disturbed, located in the NW¼SW¼NW¼ sec. 3, T. 8 N., R. 16 W. (Spring Lake Township);

A1—0 to 3 inches, very dark gray (10YR 3/1) sand; weak, fine, granular structure; very friable; medium acid; abrupt, smooth boundary.

A2—3 to 9 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; medium acid; clear, irregular boundary.

B21ir—9 to 15 inches, dark-brown (7.5YR 4/4) sand; single grain; loose; strongly acid; clear, wavy boundary.

B22ir—15 to 20 inches, strong-brown (7.5YR 5/6) sand; single grain; loose; strongly acid; clear, wavy boundary.

B3—20 to 26 inches, yellowish-brown (10YR 5/6) sand; single grain; loose; medium acid; clear, wavy boundary.

C—26 to 66 inches, very pale brown (10YR 7/4) sand; single grain; loose; medium acid.

The solum is 20 to 40 inches thick. In reaction it ranges from slightly acid to strongly acid.

In undisturbed areas a 1- to 2-inch O horizon of black (10YR 2/1 or 7.5YR 2/1) organic material is at the surface.

The color of the A1 horizon ranges to black (10YR 2/1), and that of the A2 horizon to light gray (10YR 7/2).

In cultivated areas the Ap horizon, a mixture of the O, A1, and A2 horizons, is very dark grayish brown (10YR 3/2).

Where the B21ir horizon is less than 3 inches thick, the color ranges to dark brown (7.5YR 3/2) or dark reddish brown (5YR 3/3). The color of the B22ir ranges to dark brown (7.5YR 4/4) or dark yellowish brown (10YR 4/4).

Thin color bands occur in the C horizon in some profiles. The color of the C horizon ranges to yellowish brown (10YR 6/4) or very pale brown (10YR 7/3). Mottles occur below a depth of 40 inches in some profiles. The reaction of this horizon is slightly acid or medium acid.

Rubicon soils formed in the same kind of material as Chelsea, Croswell, and Deer Park soils. Rubicon soils lack the multiple Bt horizons that are typical of Chelsea soils. They are better drained than Croswell soils, and they lack the mottles in the B22ir horizon that are typical of Croswell soils. They have a darker colored and better developed Bir horizon than Deer Park soils.

Rubicon sand, 0 to 6 percent slopes (RsB).—This soil, one of the most extensive in the county, occurs as large areas on outwash plains and lake plains, as long narrow areas on dunes, and as small, irregularly shaped areas on parts of the uplands.

This soil has the profile described as typical of the series, but variations in the profile occur from place to place. In some areas in the southern and eastern parts of the county, the subsoil lacks the brownish and reddish colors. In some areas on the outwash plains and lake plains, the underlying material is gravelly. Fine-textured underlying material occurs at a depth of 3 to 4 feet in some places; in others the upper part of the subsoil is a darker brown that is typical; and in still others the subsoil contains fragments of cemented material. Soil blowing has removed the surface and subsurface layers from some small areas, and in these places the present surface layer is dark-brown sand. In other places wind-blown material has been deposited on the surface. Included in mapping were spots of moderately well drained Croswell and somewhat poorly drained Au Gres soils, which occur in depressions and drainageways, and spots of Chelsea soils, which are finer textured than Rubicon soils. Also included were small spots that are severely eroded.

Fertility is very low, the available water capacity is very low, and permeability is rapid. The soil blows readily if the surface is exposed.

Although this soil is not suitable for most crops, specialty crops, including flowers, seedling trees, melons, pickling cucumbers, and small fruits, are grown in a few places where supplemental irrigation is available. Many areas are covered with second-growth oak, white pine, and aspen. Other areas, once cultivated but now abandoned, have grown up to black oak, white oak, aspen, sassafras, and fire cherry. Red pine, jack pine, and white pine have been planted for timber, and Scotch pine for Christmas trees. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Rubicon sand, 6 to 18 percent slopes (RsD).—This soil occurs as long, narrow ridges on plains and as small areas on upland hillsides. Both the size of individual areas and the total extent are greater on the plains than on the uplands.

The surface layer in some areas is loamy sand, and the lower part of the subsoil in some places is mottled. The subsoil is less well differentiated than that in the typical profile. Where soil blowing has removed the original surface and subsurface layers, the present layer is dark-brown sand. In depressions and protected pockets, the surface layer is thicker and darker colored than is typical. Included in mapping were spots of Chelsea soils, which have

thin bands of fine-textured material below a depth of 36 inches. Also included are severely eroded spots in which the surface layer is pale-brown sand.

Fertility is very low, the available water capacity is very low, and permeability is rapid. The soil blows readily if the surface is exposed.

This soil is not suitable for crops. Some of it is now covered with second-growth trees, and some with a mixture of beachgrass, fire cherry, sumac, and scrub oak. Pine, either for timber or for Christmas trees, has been planted in some areas. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Rubicon sand, 18 to 45 percent slopes (RsF).—This soil occurs mainly on ridges and on the sides of deep drainageways in the western part of the county. Slopes are short and steep.

Most areas of this soil are eroded to the extent that the present surface layer is dark-brown sand. All horizons in the profile are thinner and less well differentiated than those in the typical profile. Included in mapping were spots of Chelsea soils, which have thin bands of finer textured material within 3 feet of the surface; severely eroded spots in which the surface layer is pale-brown sand; and protected spots in which the surface layer is thicker and darker colored than is typical.

This soil is not suitable for crops, but it does have value as a source of timber products, as wildlife habitat, and for recreational uses. It needs to be protected by a cover of trees or other permanent vegetation. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Sand Pits

Sand pits (Sd) consists of scattered areas that have been excavated to obtain sand for fill material, for borrow, and for other commercial uses. The areas vary in size and shape. Some large pits along Lake Michigan are sources of sand used in foundry castings. Free water stands in some of the pits. The loose, dry sand, especially in the pits near Lake Michigan, is highly susceptible to soil blowing.

If stabilized and revegetated, these areas are useful as wildlife habitat and as recreation areas. They are not suitable for farming. (Capability unit VIIIs–1 (Sa); woodland suitability group Y)

Saugatuck Series

The Saugatuck series consists of somewhat poorly drained and poorly drained soils that occur on outwash plains and lake plains, mainly in the western part of the county. These soils have cemented layers in the lower part of the subsoil. In Ottawa County, Saugatuck soils were mapped only as part of the complex called Au Gres-Saugatuck sands, 0 to 6 percent slopes.

In a typical profile, the surface layer consists of black sand and is about 4 inches thick. Below it is a 3-inch subsurface layer of reddish-gray fine sand. The subsoil consists of fine sand and is 16 inches thick. The uppermost inch is black and very friable; the next inch is very dusky red and very friable. The next 10 inches is dark reddish brown to reddish yellow and is weakly to strongly cemented. Below the cemented layers is a 4-inch layer of loose fine sand that is reddish yellow blotched with darker colors. The underlying material, at a depth of 23 inches, is very pale brown over pale brown fine sand; it extends to a depth of at least 60 inches.

Fertility is low, and the available water capacity is low. Runoff is very slow. Water ponds in slight depressions for short periods after heavy rains. Permeability is rapid in the surface layer and the upper part of the subsoil and slow in the cemented layers. The water table fluctuates. It is within a few feet of the surface part of the year but drops several feet in summer. The cemented layers restrict the growth of roots. The soils blow readily when dry.

A large part of the acreage has been cleared but is now idle. Some areas are wooded. The native vegetation is a mixture of hardwoods and conifers, including oak, white pine, sweetgum, and birch. Trees grow slowly and are shallow rooted and of low quality. Blueberries are grown in some areas.

Typical profile of Saugatuck sand, undisturbed, located in the NW¼NW¼ sec. 30, T. 7 N., R. 15 W. (Robinson Township, 525 feet E. and 600 feet S. of NW. corner of section, at junction of 144th St. and Michigan Route 45):

O2—2 inches to 0, mat of partly decomposed leaves and twigs and roots.

A1—0 to 4 inches, black (N 2/0) sand; very weak, granular structure; very friable; some light-gray (N 7/0) sand; a mat of fine roots makes up about 40 percent of horizon; very strongly acid; abrupt, smooth boundary.

A2—4 to 7 inches, reddish-gray (5YR 5/2) fine sand; common, fine, distinct, dark reddish-brown (5YR 3/3) mottles; very weak, medium, subangular blocky structure; very friable; contains a mass of fine roots; very strongly acid; abrupt, wavy boundary.

B21h—7 to 8 inches, black (5YR 2/1) fine sand; weak, fine and medium, subangular blocky structure; very friable; contains many fine roots; very strongly acid; abrupt, wavy boundary.

B22hir—8 to 9 inches, very dusky red (2.5YR 2/2) fine sand; medium, subangular blocky structure; very friable; contains many fine roots; very strongly acid; abrupt, wavy boundary.

B23irm—9 to 11 inches, dark reddish-brown (2.5YR 2/4) fine sand; massive, parting to moderate to strong, thin, platy structure; weakly to strongly cemented (ortstein); a few tongues, 2 to 4 inches thick, extend into the B24irm horizon; very strongly acid; abrupt, wavy boundary.

B24irm—11 to 13 inches, dark reddish-brown (5YR 3/4 or 2.5YR 3/4) fine sand; massive, parting to moderate, thin, platy structure; strongly cemented (ortstein); a mass of fine, flat roots between horizontal planes and plates; very strongly acid; abrupt, wavy boundary.

B25irm—13 to 19 inches, reddish-yellow (7.5YR 6/6) fine sand; streaks of dark reddish brown (5YR 3/4) at irregular intervals; very few roots; massive; strongly cemented (ortstein); very strongly acid; gradual, irregular boundary.

B3—19 to 23 inches, reddish-yellow (7.5YR 7/6) fine sand; single grain; loose; contains numerous vertical stems or channels, from less than 1 millimeter to about 3 millimeters in diameter, and blotches of dark reddish brown (5YR 3/3) and dark brown (7.5YR 4/4); channels of stems are 1 to 3 inches long; the color is strongest or reddest in the center of the channel and fades gradually toward the outside; very strongly acid; clear, wavy boundary.

C1—23 to 30 inches, very pale brown (10YR 7/4) fine sand; dark-brown (7.5YR 4/4) channels or tubes, from less than 1 millimeter to about 3 millimeters in diameter and from ½ inch to 5 inches in length, plentiful in upper part and decreasing in number with depth; single grain; loose; strongly acid; gradual, wavy boundary.

C2—30 to 60 inches, pale-brown (10YR 6/3) fine sand; few, fine, vertical channels or tubes of dark brown (7.5YR 4/4); single grain; loose; strongly acid.

The solum is 18 to 60 inches thick but dominantly between 20 and 40 inches. The texture throughout is fine sand or medium sand. In reaction the solum ranges from medium acid to extremely acid but is most commonly strongly or very strongly acid. The reaction of the C horizon is medium acid to strongly acid.

In cultivated areas there is an Ap horizon that is very dark brown (10YR 2/2) or dark gray (10YR 4/1).

The color of the A2 horizon ranges to white (N 8/0 or 10YR 8/1), light gray (10YR 6/1), or pinkish gray (7.5YR 7/2 or 5YR 7/2). Tongues of A2 material extend into the Bh and Birm horizons in some profiles.

Color, thickness, and degree of cementation in the Bh horizon vary within short horizontal distances. In the Birm horizon, the hue is 2.5YR, 5YR, or 7.5YR, the value is 2 to 6, and the chroma is 1 to 6. The thickness of the cemented (Birm) horizons ranges from 9 to 28 inches.

The color of the C horizon ranges to light brownish gray (10YR 6/2) or light yellowish brown (10YR 6/4).

Saugatuck soils occur near Croswell, Au Gres, and Granby soils, none of which have the continuous cemented Birm horizon that is characteristic of Saugatuck soils.

Selkirk Series

The Selkirk series consists of somewhat poorly drained soils that occur on lake plains. These soils developed in deposits of limy clay or silty clay.

In a typical profile, the surface layer consists of dark-gray loam and is about 8 inches thick. The subsoil is about 14 inches thick. The upper 4 inches is a mixture of light brownish-gray, firm loam and brownish-yellow, firm silty clay loam. The lower 10 inches is yellowish-brown, mottled, very firm silty clay. The underlying material, at a depth of 22 inches, is yellowish-brown, mottled, limy silty clay.

Fertility is high, and the available water capacity is moderate. Runoff is slow, and water ponds in depressions. Permeability is slow. The soils warm up and dry out slowly in spring. Mottling in the subsoil is evidence of prolonged saturation. Because of the slow permeability, it is difficult to drain these soils well enough to make them suitable for crops. Tilth deteriorates without careful management. Frost damage to crops is a hazard.

Some of the acreage is cropland, some is pasture, and some is woodland. Hay and pasture crops do well. The native vegetation consists mainly of lowland hardwoods, including maple, ash, beech, and elm; some white pine and some hemlock are included also. Trees grow slowly and are shallow rooted.

Typical profile of Selkirk loam, 2 to 6 percent slopes, cultivated, located in the SE¼NW¼SE¼ sec. 17, T. 8 N., R. 14 W. (Polkton Township):

Ap—0 to 8 inches, dark-gray (10YR 4/1) loam; weak, medium, granular structure; friable; mildly alkaline; abrupt, smooth boundary.

A&B—8 to 12 inches, light brownish-gray (10YR 6/2) loam (A part), which occurs in cracks and surrounds or nearly surrounds isolated peds of brownish-yellow (10YR 6/6) silty clay loam (B part); moderate, medium, subangular blocky structure; firm; neutral; clear, irregular boundary.

B2t—12 to 22 inches, yellowish-brown (10YR 5/4) silty clay; many, medium, distinct, gray (10YR 6/1) and light brownish-gray (10YR 6/2) mottles; strong, fine, angular blocky structure; very firm; films of gray (10YR 5/1) clay in cracks, voids, and root channels; mildly alkaline; clear, wavy boundary.

C—22 to 50 inches, yellowish-brown (10YR 5/4) silty clay; many, medium, distinct, light-gray and gray (10YR 7/1 and 6/1) mottles; strong, medium, angular blocky structure; very firm; streaks and coatings of gray (10YR 5/1) lime; calcareous.

The solum is 16 to 28 inches thick. In reaction it ranges from slightly acid to moderately alkaline.

In undisturbed areas the profile has an A1 and an A2 horizon, each 3 to 5 inches thick. The color of the A1 horizon is very dark grayish brown (10YR 3/2) or very dark gray (10YR 3/1), and the texture is dominantly loam but is silt loam or clay loam in some places. The color of the A2 horizon is gray (10YR 5/1 or 5YR 5/1), pinkish gray (7.5YR 5/2), or light brownish gray (10YR 6/2).

The color of the Ap horizon ranges to dark grayish brown (10YR 4/2) or very dark grayish brown (10YR 3/2).

In the B horizon, the color has a hue of 10YR to 5YR, a value of 4 to 6, and a chroma of 3 to 6. The texture of this horizon is silty clay or clay.

The color of the C horizon ranges to pinkish gray (5YR 6/2 or 7.5YR 6/2) mottled with reddish brown (5YR 6/3) or red (2.5YR 5/8). The texture of the C horizon is silty clay or clay.

Selkirk soils are in the same drainage class as Kawkawlin and Bowers soils. They have finer textured B2 and C horizons than either Kawkawlin or Bowers soils. Selkirk soils occur near Allendale soils. They are finer textured in the upper part of the B horizon than Allendale soils. They are less poorly drained and less gray than Toledo soils.

Selkirk loam, 0 to 2 percent slopes (SeA).—This soil is on lake plains. Associated with it are Hettinger, Pinconning, Allendale, and Bowers soils.

In undisturbed areas the color of the surface layer is dark grayish brown or very dark gray. In some places the texture of the surface layer is silt loam or clay loam. Clay loam is most likely to be found where the soil has been cultivated intensively. Included in mapping were spots in which drainage is poor and the surface layer is thicker and the color darker than is typical. Also included were spots in which about 2 feet of fine sandy loam overlies the silty clay substratum. Spots of Allendale and Pinconning soils are other inclusions.

Fertility is high, the available water capacity is moderate, and permeability is slow. Subsurface drainage is needed for most crops, and surface drainage is needed in many places. Establishing artificial drainage is difficult because of the slow permeability. Tilth deteriorates if the soil is worked when wet. The fine-textured subsoil restricts the root zone. The soil warms up and dries out slowly in spring. Frost damage to crops is a hazard.

Most areas of this soil are small and are used for crops or pasture along with the surrounding soils. Careful management, including drainage, is needed if crops are grown. Pasture plants do well, but animal traffic when the soil is wet is likely to cause compaction. Trees grow slowly and have shallow roots. Limitations for construction are numerous. (Capability unit IIIw–2 (1b); woodland suitability group Z)

Selkirk loam, 2 to 6 percent slopes (SeB).—This soil is on lake plains. Slopes in some areas are long and uniform and generally of no more than 3 percent gradient; slopes in other areas are short, irregular, and choppy. Associated with this soil are Allendale, Hettinger, and Pinconning soils.

This Selkirk soil has the profile described as typical of the series. In undisturbed areas the color of the surface layer is dark grayish brown or very dark gray. In some places the texture of the surface layer is silt loam or clay loam. Clay loam is most likely to be found where the soil

has been cultivated intensively. Where the soil is eroded, the surface layer is yellowish-brown, mottled silty clay loam; it has very poor tilth and is sticky and slippery when wet and hard and crusted when dry. Included in mapping were spots of Hettinger and Pinconning soils, which are in depressions and drainageways and are poorly drained, and of Allendale soils, which have about 2 feet of sand above the silty clay substratum. Also included are spots in which about 2 feet of fine sandy loam overlies the substratum. Other included areas have slopes of more than 6 percent or less than 2 percent.

Fertility is high, the available water capacity is moderate, and permeability is slow. Ponded water in depressions delays tillage and prevents or retards the growth of crops. Seedlings winterkill when ice forms in such spots. Subsurface drainage is needed for most crops, and surface drainage is needed in many places. The soil erodes readily, and erosion quickly removes the thin surface layer and exposes the silty clay subsoil. Tilth deteriorates if the soil is worked when wet. The fine-textured subsoil restricts the root zone. The soil warms up and dries out slowly in spring.

Most areas of this soil are small and are used for crops or pasture along with surrounding soils, which are commonly of the Allendale and Pinconning series. Careful management, including drainage, is needed if crops are grown. Pasture plants do well, but animal traffic when the soil is wet can cause compaction. Trees grow slowly and have shallow roots. Limitations for construction are numerous. (Capability unit IIIw–2 (lb); woodland suitability group Z)

Shoals Series

The Shoals series consists of somewhat poorly drained soils on flood plains. These soils are flooded periodically and at times are inaccessible.

In a typical profile, the surface layer consists of dark grayish-brown loam and is about 8 inches thick. The subsoil is about 35 inches thick. It is made up of 8 inches of dark-gray, mottled, friable silt loam; 8 inches of gray, mottled, firm silty clay loam; and 9 inches of dark-brown, mottled, very firm silty clay loam. The underlying material, at a depth of about 43 inches, is light brownish-gray, mottled fine sandy loam; it extends to a depth of at least 60 inches.

Fertility is high, the available water capacity is high, permeability is moderately slow, and runoff is very slow to ponded. The water table is seasonally high, and periodic flooding is a hazard. Crops are subject to frost damage.

Some of the acreage is cropland, some is pasture, and some is woodland. Drainage is needed if crops are grown. Pastures have high carrying capacity. Trees are slow growing, shallow rooted, and of low quality. The native vegetation is a mixture of lowland hardwoods, including elm, ash, red maple, silver maple, cottonwood, sycamore, willow, and alder brush.

Typical profile of Shoals loam, cultivated, located in the SW¼SW¼SW¼NE¼ sec. 23, T. 8 N., R. 15 W. (Crockery Township):

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) loam; common, medium, faint, very dark gray (10YR 3/1) mottles; moderate, medium, granular structure; friable; moderately alkaline; abrupt, smooth boundary.

B1g—8 to 16 inches, dark-gray (10YR 4/1) silt loam; many, medium, distinct, light-gray (10YR 7/1) and many, medium, faint, very dark grayish-brown (10YR 3/2) mottles; moderate, medium, subangular blocky structure; friable; moderately alkaline; gradual, wavy boundary.

B21g—16 to 24 inches, gray (10YR 5/1) silty clay loam; common, medium, faint, light-gray (10YR 6/1) mottles and common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, medium, angular blocky structure; firm; mildly alkaline; clear, wavy boundary.

B22g—24 to 43 inches, dark-brown (7.5YR 4/4) silty clay loam; many, coarse, distinct, light brownish-gray (10YR 6/2) mottles and many, medium, distinct, gray (10YR 5/1) mottles; moderate, medium, angular blocky structure; very firm; mildly alkaline; clear, wavy boundary.

Cg—43 to 60 inches, light brownish-gray (10YR 6/2) fine sandy loam; many, medium, distinct, yellowish-brown (10YR 5/4) mottles and many, medium, faint, gray (10YR 6/1) mottles; structureless (massive); friable; moderately alkaline; gradual, wavy boundary.

The solum is 20 to 50 inches thick. In reaction it ranges from slightly acid to moderately alkaline.

The texture of the Ap horizon is loam, silt loam, or sandy loam. The color of this horizon ranges to very dark grayish brown (10YR 3/2) or brown (10YR 5/3), and the mottles are faint to distinct.

In the B and C horizons, the color has a hue of 10YR or 7.5YR, a value of 3 to 6, and a chroma of 1 to 4. The texture is dominantly light silty clay loam or silt loam, but strata of sandy loam, loam, or clay loam occur at a depth of 20 or more inches.

Shoals and Sloan soils formed in similar material and occur near each other. Shoals soils are less poorly drained than Sloan soils, which are on lower parts of flood plains. Shoals soils differ from Ceresco and Algansee soils in having a B2g horizon of silty clay loam.

Shoals loam (0 to 2 percent slopes) (Sh).—This soil occurs on the flood plains of streams throughout the county. It is slightly above the first bottoms. Associated with it are Cohoctah, Glendora, and Sloan soils.

The color of the surface layer is dark grayish brown or very dark gray. In places the texture ranges from loam to silt loam or sandy loam within short distances. In some areas, mainly near Hudsonville, a substratum of muck or peat, from a foot to several feet in thickness, occurs at a depth of 3 to 5 feet. In other areas sand and gravel occur at a depth of 3 to 5 feet. Included in mapping were areas of poorly drained Sloan soils, which are in depressions, sloughs, meander scars, and pockets, and also areas of Ceresco soils.

Fertility is high, and the available water capacity is high. Artificial drainage is needed. Periodic flooding and variations in texture make it difficult to install and maintain drainage facilities.

If adequately drained this soil is suited to corn and other crops. Many areas have been cleared and drained and are cultivated. Some cleared areas are now idle and are covered with grass, weeds, and brush. Other areas are in pasture, and others are still wooded. Trees are slow growing and shallow rooted. (Capability unit IIIw–12 (L–2c); woodland suitability group O)

Sims Series

The Sims series consists of poorly drained, level to depressional soils that occur on uplands and plains. These

soils developed in deposits of clay loam or silty clay loam.

In a typical profile, the surface layer consists of very dark gray loam and is about 9 inches thick. The subsoil is about 21 inches thick. The upper 11 inches is dark greenish-gray, mottled, firm clay loam, and the lower 10 inches is strong-brown, mottled, very firm clay loam. The underlying material, at a depth of about 30 inches, consists of yellowish-brown, mottled clay loam that is calcareous below a depth of about 36 inches. This layer extends to a depth of several feet.

Fertility is high, the available water capacity is high, permeability is moderately slow, and runoff is slow to ponded. The water table is near the surface much of the year. Artificial drainage is needed for crops, and frost damage is a hazard.

Most of the acreage is drained and used for crops. Short rotations in which row crops are dominant are usual. Undrained areas are used for hay or pasture or are wooded. The native vegetation is a mixture of lowland hardwoods, including elm, ash, red maple, silver maple, swamp white oak, and some sycamore.

Typical profile of Sims loam, cultivated, located in the SW¼SW¼SE¼SE¼ sec. 7, T. 6 N., R. 13 W. (Georgetown Township):

Ap—0 to 9 inches, very dark gray (10YR 3/1) loam; moderate, fine, granular structure; friable; neutral; abrupt, smooth boundary.

B21g—9 to 20 inches, dark greenish-gray (5GY 4/1) clay loam; few greenish-gray (5GY 5/1) clay films and few, medium, prominent, dark-brown (7.5YR 4/4) mottles; moderate, medium, subangular blocky structure; firm; mildly alkaline; clear, wavy boundary.

B22—20 to 30 inches, strong-brown (7.5YR 5/6) heavy clay loam; many, medium, prominent, greenish-gray (5G 6/1) mottles; moderate, medium, angular blocky structure; very firm; mildly alkaline; clear, wavy boundary.

C1—30 to 36 inches, yellowish-brown (10YR 5/4) clay loam; many, medium, prominent, greenish-gray (5GY 6/1) mottles; moderate, medium, subangular blocky structure; firm; moderately alkaline; clear, wavy boundary.

C2——36 to 50 inches, yellowish-brown (10YR 5/4) clay loam; many, medium, prominent, greenish-gray (5G 6/1) mottles; moderate, medium, subangular blocky structure; firm; moderately alkaline and calcareous.

The solum is 20 to 40 inches thick.

The color of the Ap horizon ranges to very dark brown (10YR 2/2). Some profiles have, below the Ap horizon, a black (10YR 2/1) or very dark gray (10YR 3/1) A1 horizon 1 to 4 inches thick. The lower boundary of the A1 horizon is clear or abrupt.

The matrix color of the B horizon ranges to grayish brown (10YR 5/2), and the texture ranges to heavy silty clay loam.

The texture of the C horizon is clay loam or silty clay loam.

Sims soils formed in the same kind of material as Kawkawlin and Hettinger soils. They are more poorly drained than Kawkawlin soils, and they lack the thin layers of silt loam in the C2 horizon that are characteristic of Hettinger soils. Sims soils are in the same drainage class as Tonkey soils, which are coarser textured throughout.

Sims loam (0 to 2 percent slopes) (Sm).—This nearly level to depressional soil occurs on both uplands and plains throughout the county. Associated with it are Nester, Morley, Kawkawlin, and Blount soils, all of which are better drained than Sims soils.

Some areas of this soil have a surface layer of clay loam, silt loam, or sandy loam. In some depressed areas at the base of slopes, the surface layer is thicker than that in the typical profile because of an accumulation of overwash. In other areas erosion has made the surface layer thinner and lighter colored than is typical. Included in mapping were scattered spots of Breckenridge and Brevort soils, which are coarser textured than Sims soils; of Kawkawlin soils, which are better drained; and of Hettinger soils, which contain layers of silty material. Also included were areas that have short slopes of 3 or 4 percent.

Fertility is high, the available water capacity is high, permeability is moderately slow, and runoff is slow to ponded. Artificial drainage is needed for crops. Frost damage to crops is a hazard.

If adequately drained, this soil is suited to most crops. Corn, small grain, and hay are the common crops. Cropping systems are usually short and consist largely of row crops. Some areas, mostly undrained, are used only for hay or pasture, and some are still wooded. (Capability unit IIw–2 (1.5c); woodland suitability group P)

Sloan Series

The Sloan series consists of poorly drained, nearly level to depressional soils on flood plains. These soils are flooded periodically, and some areas are inaccessible.

In a typical profile, the surface layer consists of very dark gray loam and is about 12 inches thick. The subsoil, about 6 inches thick, consists of gray, mottled, firm light silty clay loam. The upper 24 inches of the underlying material is dark-gray, mottled silt loam. Below this is light brownish-gray, mottled loam that extends to a depth of at least 60 inches.

Fertility is high, the available water capacity is high, permeability is moderately slow, and runoff is slow to ponded. The water table is high, and artificial drainage is needed. Flooding and frost damage are hazards.

Some of the acreage is cropland, some is pasture, and some is woodland. Corn is the major crop. Many areas are in native pasture. Others are covered with low-quality trees. The native vegetation is a mixture of lowland hardwoods, including elm, red maple, silver maple, cottonwood, willow, and alder brush.

Typical profile of Sloan loam, undisturbed, located in the NE¼SW¼NE¼ sec. 23, T. 8 N., R. 15 W. (Crockery Township):

A1—0 to 12 inches, very dark gray (10YR 3/1) loam; weak, fine, granular structure; friable; neutral; gradual, wavy boundary.

Bg—12 to 18 inches, gray (10YR 5/1) light silty clay loam; few, medium, distinct, yellowish-brown (10YR 5/4) mottles and many, medium, faint, dark-gray (10YR 4/1) mottles; weak, medium, subangular blocky structure; firm; mildly alkaline; gradual, wavy boundary.

C1g—18 to 42 inches, dark-gray (10YR 4/1) silt loam; many, medium, faint, gray (10YR 5/1) mottles; weak, fine, subangular blocky structure; friable; moderately alkaline.

C2g—42 to 60 inches, light brownish-gray (10YR 6/2) loam; few, fine, faint, pale-brown (10YR 6/3) mottles; structureless (massive); friable; moderately alkaline.

The reaction of the solum ranges from neutral to moderately alkaline. That of the C horizon is mildly or moderately alkaline. In only a few places is the C horizon calcareous.

The color of the A1 or Ap horizon ranges to black (10YR 2/1). Some profiles include a 4- to 6-inch A12 horizon. Organic coatings on peds extend into the C horizon in some places.

In both the B and C horizons, the dominant texture is light loam, silt loam, or light silty clay loam (clay content between 18 and 30 percent). Thin strata of sandy loam, fine sand, and fine sandy loam occur below a depth of 24 inches

in some places. Thicker strata of sand or, less commonly, of gravel occur below a depth of 36 inches in some places.

Sloan soils occur near Shoals, Ceresco, Glendora, and Cohoctah soils. Sloan soils occupy lower positions on the landscape than Shoals soils and are more poorly drained. They differ from Ceresco, Glendora, and Cohoctah soils in having a moderately fine textured Bg horizon.

Sloan loam (0 to 2 percent slopes) (Sn).—This soil is on the lowest parts of flood plains. Associated with it are Cohoctah, Glendora, Shoals, and Ceresco soils.

In most areas the surface layer is very dark gray loam, but in some areas the texture of this layer is clay loam, silt loam, or sandy loam. In protected pockets, meander scars, and sloughs, where water ponds for long periods of time, the entire profile is finer textured than is typical. In some depressed areas, mostly at the outer margin of the flood plain, a 12-inch to 15-inch layer of organic material is at the surface. In some places a layer of organic material is buried at a depth of 3 to 5 feet. In the western part of the county are some areas in which the texture below a depth of 12 to 18 inches is coarser than is typical. Included in mapping were spots of Shoals soils, which are less poorly drained, and of Glendora and Algansee soils, which are coarser textured than Sloan soils. Also included are some areas that have slopes between 2 and 4 percent.

Fertility is high, the available water capacity is high, permeability is moderately slow, and runoff is slow to ponded. Artificial drainage is needed if crops are grown. Because of periodic flooding and variations in texture, installation and maintenance of drainage facilities are difficult. Frost damage to crops is a hazard.

Many areas of this soil have been cleared, drained, and cultivated. Corn is the major crop. Some areas are used only for native pasture, and some are still wooded. Pastures have high carrying capacity. Trees are generally slow growing and shallow rooted. Wildlife that needs a wetland habitat is abundant. Some areas have been developed for recreational use. (Capability unit IIIw–12 (L–2c); woodland suitability group O)

Spinks Series

The Spinks series consists of well-drained soils that occur both on plains and on uplands in the southeastern part of the county. These soils developed in deposits of sand and loamy sand.

In a typical profile, the surface layer consists of dark grayish-brown loamy sand and is about 7 inches thick. A 6-inch subsurface layer consists of pale-brown sand. The upper 8 inches of the subsoil consists of yellowish-brown, friable heavy loamy sand. Beginning at a depth of 21 inches is a horizon made up of alternate layers of pale-brown, loose sand and dark-brown, friable heavy loamy sand; this horizon extends to a depth of 58 inches. The underlying material is light yellowish-brown loamy sand; it extends downward several feet.

Fertility is low, the available water capacity is low, and permeability is rapid. Runoff is slow to medium, depending on the slope. The organic-matter content is low. Crops generally show the effects of moisture deficiency late in the growing season. The soils are susceptible to water erosion and to blowing.

Some of the acreage is cropland, some is pasture, and some is woodland. The native vegetation is a mixture of upland hardwoods, including oak, hickory, and maple. Limitations for construction are few.

Typical profile of a Spinks loamy sand, cultivated, located in the NE¼SW¼SW¼ sec. 13, T. 7 N., R. 13 W. (Tallmadge Township):

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loamy sand; weak, medium, granular structure; very friable; slightly acid; abrupt, smooth boundary.

A2—7 to 13 inches, pale-brown (10YR 6/3) sand; structureless (single grain); loose; medium acid; clear, irregular boundary.

Bt—13 to 21 inches, yellowish-brown (10YR 5/6) heavy loamy sand; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

A'2&B't—21 to 58 inches, alternate layers of pale-brown (10YR 6/3) sand (A'2 part) and dark-brown (7.5YR 4/4) heavy loamy sand (B't part). A'2 material is structureless (single grain), loose, and medium acid; layers have abrupt, smooth lower boundary. B't material is structureless (massive), friable, and slightly acid; lower boundary is clear and wavy.

C—58 to 66 inches, light yellowish-brown (10YR 6/4) loamy sand; structureless (massive); very friable; mildly alkaline.

The reaction of the solum below the Ap horizon is medium acid to neutral but is predominantly medium acid or slightly acid. The reaction of the Ap horizon depends on how much lime has been applied. That of the C horizon ranges from slightly acid to mildly alkaline.

In undisturbed areas there is a 3- to 5-inch A1 horizon that is very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark gray (10YR 4/1).

The color of the Ap horizon ranges to dark brown (10YR 4/3). In the A2 horizon the color ranges to light yellowish brown (10YR 6/4), and the texture is sand or loamy sand.

The depth to the Bt horizon ranges from 12 to about 24 inches. The number of B't layers in the A'2&B't horizon varies between 4 and 15 or more. In thickness these layers range from half an inch to about 5 inches; the total thickness is more than 6 inches.

Spinks soils occur near Boyer, Oshtemo, and Hillsdale soils. They are much thinner and coarser textured than any of these other soils and also are less acid than Hillsdale soils. Spinks soils and Montcalm soils formed in similar material and occur together. Spinks soils lack the Bir horizon that is characteristic of Montcalm soils.

Spinks loamy sand, 0 to 2 percent slopes (SpA).—This soil occurs on plains and uplands in the southeastern part of the county.

This soil has the profile described as typical of the series. In some places the underlying material is gravelly. Included in mapping were spots of Boyer soils, which are underlain with alkaline gravel at a depth of less than 3½ feet, and spots of Oshtemo soils, which have acid, gravelly underlying material at a depth of more than 3½ feet. Also included were areas that have slopes of more than 2 percent, and some in which the reaction is more acid than is typical of Spinks soils.

Fertility is low, the organic-matter content is low, and the available water capacity is low. Soil blowing is a hazard.

Most areas of this soil have been cleared. Some are now used for crops, and some are idle and have a cover of grass and weeds. Cropping systems commonly include more than 2 years of hay. Limitations for construction are few. (Capability unit IIIs–3 (4a); woodland suitability group E)

Spinks loamy sand, 2 to 6 percent slopes (SpB).—This soil occurs on plains and uplands in the southeastern part of the county.

The color of the surface layer in some areas is dark yellowish brown, and the texture in some areas is sandy loam. In some areas the underlying material is limy gravel. Included in mapping were spots of Boyer soils in which limy gravel is within 3½ feet of the surface, and spots of Oshtemo soils in which the underlying material is acid gravel. Also included are areas that have slopes of more than 6 percent or of less than 2 percent, severely eroded spots, and areas in which the reaction is less acid than is usual for Spinks soils.

Fertility is low, and the available water capacity is low. The organic-matter content is low. Tilth deteriorates readily, and soil blowing is a hazard.

Nearly all areas of this soil have been cleared and are cultivated. Corn, small grain, and hay are the common crops. Cropping systems commonly consist largely of small grain and hay. Some areas are idle and have a cover of grass and weeds. A few areas are still wooded. Limitations for construction are few. (Capability unit IIIs–4 (4a); woodland suitability group E)

Spinks loamy sand, 6 to 12 percent slopes (SpC).—This soil occurs on uplands and on long, narrow breaks on plains in the southeastern part of the county.

Where this soil is eroded, the surface layer is dark yellowish-brown loamy sand or light sandy loam. The most severely eroded spots are sandy. Included in mapping were spots of Boyer and Oshtemo soils and also some areas that have slopes of more than 12 percent or of less than 6 percent.

Fertility is low, and the available water capacity is low. The organic-matter content is low. The soil is susceptible to both water erosion and blowing.

Some areas of this soil are cultivated, some are idle or are used for hay or pasture, and some are still wooded. Long cropping systems that consist largely of small grain and hay are usual. (Capability unit IIIe–9 (4a); woodland suitability group E)

Spinks and Montcalm loamy sands, 12 to 18 percent slopes (SsD).—These soils occur on uplands and on long, narrow ridges and breaks on plains. Each individual area consists dominantly of either Spinks loamy sand or Montcalm loamy sand. The two soils are of similar origin and are similar in drainage as well as in texture. The main difference between them is that the Montcalm soil is brighter colored in the upper part of the subsoil.

Some areas of this unit are eroded to such an extent that the original surface layer and subsurface layer and part of the subsoil are gone. In some places the present surface layer is dark yellowish-brown sandy loam or loamy sand, and the stratified layer of sand and loamy sand is immediately below it. Even where there has been no significant erosion, the horizons are thinner than in the typical profiles of the respective series. There are some areas in which clay loam occurs at a depth of 36 inches and others in which the texture of the subsoil is dominantly fine sand or very fine sand. In other areas the surface layer consists of reddish-brown sandy clay loam or sandy loam, and limy sand and gravel occur at a depth of 2 or 3 feet. Included in mapping were small areas in which the slope is more than 18 percent or less than 12 percent.

Fertility is low, the available water capacity is low, and permeability is rapid or moderately rapid. The organic-matter content is low. The slope makes it difficult to use machinery effectively.

Most areas of this soil have been cleared and cultivated in the past. The only areas now cultivated are a few small areas that are within field dominated by less steep soils. Much of the acreage is idle or is used for hay or pasture. A permanent cover of vegetation is needed. (Capability unit IVe–9 (4a); Spinks soil in woodland suitability group E, Montcalm soil in woodland suitability group C)

Spinks and Montcalm loamy sands, 18 to 25 percent slopes (SsE).—These soils occur on short upland slopes and on long, narrow breaks and ridges on plains. Each individual unit consists dominantly of either Spinks loamy sand or Montcalm loamy sand. The two soils are similar in origin and are alike in drainage as well as in texture. They differ mainly in the color of the upper part of the subsoil.

Some areas of this unit are eroded to such an extent that the original surface layer and subsurface layer and part of the subsoil are gone. In some places the present surface layer is dark yellowish-brown sandy loam or loamy sand, and the stratified layer of sand and loamy sand is immediately below it. Even where the soil is less severely eroded, the horizons are thinner than those in the typical profile. There are areas in which limy clay loam occurs within 2 or 3 feet of the surface and some in which the texture is dominantly fine sand. In other areas the surface layer consists of reddish-brown sandy loam or gravelly sandy clay loam and directly overlies limy gravel. Included in mapping were small areas in which the slope is more than 25 percent or less than 18 percent.

Fertility is low, the available water capacity is low, and permeability is rapid or moderately rapid. The organic-matter content is low. In some areas tilth is poor and the surface layer is sticky when wet and hard and crusted when dry. Much water is lost through runoff, and little is absorbed. The soils are susceptible to erosion.

Most areas have been cleared and cultivated in the past. Many are now idle or are used for pasture. A few are still wooded. A permanent cover of grass or trees is needed. (Capability unit VIs–1 (4a); Spinks soil in woodland suitability group E, Montcalm soil in woodland suitability group C)

Spinks and Montcalm loamy sands, 25 to 45 percent slopes (SsF).—These soils are on short upland slopes and on the sides of deep drainageways on plains. Each individual unit consists dominantly of either Spinks loamy sand or Montcalm loamy sand. The two soils are much alike, but each differs from the less sloping soils of the same series.

In all areas the horizons are much thinner and less well differentiated than those in the typical profiles. Some areas are eroded to such an extent that the original surface layer and subsurface layer and part of the subsoil have been removed. In some places the original underlying material is at the surface. Limy sand and gravel are just below the surface layer in some areas, and in others the dominant texture throughout the profile is fine sand.

Fertility is low, the available water capacity is low, and permeability is rapid or moderately rapid. The organic-matter content is very low. Most of the water is lost through runoff, and little is absorbed. The soils are very easily eroded.

Some areas of these soils are wooded; others have been cleared but are now idle or in grass. A permanent cover of trees or grass is needed. (Capability unit VIIe–2 (4a);

Spinks soil in woodland suitability group E, Montcalm soil in woodland suitability group C)

Toledo Series

The Toledo series consists of poorly drained soils that occur on lake plains and in old glacial drainageways.

In a typical profile, the surface layer consists of very dark gray silty clay loam and is about 7 inches thick. Below it is a 5-inch layer of dark-gray, mottled silty clay loam. The subsoil, about 12 inches thick, consists of gray, mottled, firm silty clay. The upper 6 inches of the underlying material consists of pinkish-gray, mottled, limy stratified silty clay loam and silty clay. Gray, mottled, limy stratified silty clay and silt loam begin at a depth of 30 inches and extend to a depth of at least 60 inches.

Fertility is high, the available water capacity is high, permeability is slow, and runoff is very slow to ponded. The water table is high. Both surface drainage and subsurface drainage are needed. Establishing adequate subsurface drainage is difficult because of the fine texture of the subsoil. Tilth deteriorates readily. The subsurface layer and the subsoil are not readily penetrated by roots. Frost damage to crops is a hazard.

Some of the acreage is cropland, some is pasture, and some is woodland. Cropping systems generally are dominated by hay and pasture crops. The native vegetation is a mixture of lowland hardwoods, including elm, ash, red maple, silver maple, and some swamp white oak. Trees grow slowly and are shallow rooted.

Typical profile of Toledo silty clay loam, cultivated, located in the SE¼SW¼SE¼ sec. 25, T. 5. N., R. 15 W. (Holland Township):

Ap—0 to 7 inches, very dark gray (10YR 3/1) silty clay loam; moderate, medium, granular structure; firm; mildly alkaline; abrupt, smooth boundary.

A1—7 to 12 inches, dark-gray (10YR 4/1) silty clay loam; many medium, faint, gray (N 5/0) mottles and common, medium, faint, gray (10YR 5/1) mottles; moderate, medium, subangular blocky structure; firm; mildly alkaline; gradual, wavy boundary.

B2g—12 to 24 inches, gray (N 5/0 to 10YR 5/1) silty clay; common, medium, faint, light brownish-gray (10YR 6/2) mottles and few, medium, distinct, yellowish-brown (10YR 5/6) mottles; moderate, medium, angular blocky structure; firm; moderately alkaline; gradual, wavy boundary.

C1g—24 to 30 inches, pinkish-gray (7.5YR 6/2), stratified silty clay loam and silty clay; many, medium, distinct, gray (N 5/0) mottles; massive; firm; slightly calcareous; abrupt, smooth boundary.

C2g—30 to 60 inches, gray (N 5/0), stratified silty clay and very thin layers of silt loam; common, medium, faint, gray (10YR 5/1–6/1) mottles; common, medium, distinct, light-gray (10YR 7/1) mottles; moderate, medium, angular blocky structure; firm; calcareous.

The solum is 20 to about 30 inches thick.

In undisturbed areas the A1 horizon is a very dark gray (10YR 3/1) or black (10YR 2/1) and is 5 to 9 inches thick. The color of the Ap horizon ranges to black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). In places the A1 and B2g horizons are not mottled.

Thin strata of sandy and silty material occur in the lower part of the B2g horizon and in the C2g horizon in some places.

Toledo soils formed in the same kind of material as Selkirk soils, but they are at lower elevations on the lake plains than Selkirk soils and are more poorly drained. They are in the same drainage class as Sims, Hettinger, and Sloan soils, all of which are coarser textured than Toledo soils.

Toledo silty clay loam (0 to 2 percent slopes) (Tc).—This nearly level to depressional soil occurs on lake plains and in glacial drainageways.

In some places the texture of the surface layer is clay loam instead of silty clay loam. Thin layers of old alluvium occur in some places. In Holland and Zeeland Townships are areas in which a layer of dark-colored organic alluvium a foot or two in thickness is buried at a depth of about 2 feet. Some areas were slightly better drained than is typical. Included in mapping were spots of Hettinger soils in which the texture below the surface layer is silty clay loam; spots of Sloan soils, which consist of layers of silt loam, loam, and silty clay loam; and spots of Selkirk soils, which are on small knolls where the slope is 2 or 3 percent and are slightly better drained than Toledo soils.

Fertility is high, and the available water capacity is high. Permeability is slow, and runoff is very slow to ponded. Water stands on the surface after heavy rain. Both surface and subsurface drainage are needed. Establishing drainage is difficult because of the slow permeability. Tilth deteriorates readily. Planting often has to be delayed because the soil warms up and dries out slowly in spring. Frost damage to crops is a hazard.

This soil is well suited to legumes and grasses, and most of it is used for hay and pasture. A few areas are cultivated. Cropping systems include corn, small grain, and hay. There are some brushy woodlots in swampy areas. (Capability unit IIIw-1 (1c); woodland suitability group P)

Tonkey Series

The Tonkey series consists of nearly level to slightly depressional, poorly drained soils that occur on lake plains and in glacial drainageways. These soils developed in layers of sand, loamy sand, and sandy loam.

In a typical profile, the surface layer consists of very dark gray sandy loam and is about 7 inches thick. The subsoil is about 29 inches thick. The upper 19 inches consists of grayish-brown, mottled, friable sandy loam, and the lower 10 inches of pale-brown, mottled, firm, stratified sandy loam. The underlying material, at a depth of about 36 inches, is light brownish-gray, mottled, stratified loamy fine sand and fine sandy loam.

Fertility is medium, and the available water capacity is moderate. Permeability is moderate, and runoff is slow to ponded. Soil blowing is a hazard, and so is frost damage to crops.

Drained areas of these soils are used for crops; some undrained areas are used for hay and pasture, and some are still wooded. The native vegetation is a mixture of lowland hardwoods and conifers, including elm, red maple, silver maple, northern white-cedar, tag alder, and willow. Trees grow slowly and are shallow rooted.

Typical profile of Tonkey sandy loam, cultivated, located in the NW¼NE¼NE¼SW¼ sec. 33, T. 6 N., R. 14 W. (Blendon Township):

Ap—0 to 7 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

B21g—7 to 26 inches, grayish-brown (2.5Y 5/2) sandy loam; few, fine, distinct, dark reddish-brown (5YR 3/2) mottles and common, fine, distinct, dark-brown (10YR 4/3) mottles; moderate, medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

B22—26 to 36 inches, pale-brown (10YR 6/3), stratified sandy loam; many, medium, faint, light brownish-gray (10YR 6/2) mottles; moderate, medium, subangular blocky structure; firm; slightly acid; clear, wavy boundary.

Cg—36 to 50 inches, light brownish-gray (10YR 6/2), stratified loamy fine sand and fine sandy loam; many, medium, distinct, yellowish-brown (10YR 5/4) mottles; weak, medium and coarse, subangular blocky structure; friable; mildly alkaline.

The reaction of the solum ranges from medium acid to mildly alkaline.

The color of the Ap horizon ranges to very dark grayish brown (10YR 3/2) or black (10YR 2/1).

In the B horizon the matrix color ranges to gray (10YR 5/1), light gray (10YR 6/1), or grayish brown (10YR 5/2), and the texture ranges to sandy clay loam or loam. Generally, this horizon is stratified, the individual layers ranging from 2 to 12 inches in thickness. Also included in the profile are 1- to 3-inch layers of silt, very fine sand, and clay.

Tonkey soils occur near Richter, Bruce, and Hettinger soils. They are at lower elevations on the landscape than Richter soils and are more poorly drained. They have a coarser textured Cg horizon than Bruce and Hettinger soils.

Tonkey sandy loam (0 to 2 percent slopes) (To).—This soil is on lake plains and in glacial drainageways. Nearly all the areas are in the eastern half of the county.

In places the texture of the surface layer is loam or loamy fine sand instead of sandy loam. In other places the texture of the entire profile is dominantly loamy fine sand. In still others the texture is sandy loam throughout the profile, including the underlying material. Included in mapping were spots of Granby soils, which are coarser textured than Tonkey soils; spots of soils that have a thin layer of muck or peat at the surface; and areas that have short slopes of slightly more than 2 percent.

Fertility is medium, and the available water capacity is moderate. Artificial drainage is needed for most crops. Establishing drainage is difficult because of the variations in texture. Soil blowing is a hazard, and crops are likely to be damaged by frost.

If drained this soil is suited to most crops. Much of the acreage has been cleared and cultivated. Some areas are in pasture or are still wooded. (Capability unit IIw–6 (3c); woodland suitability group W)

Tuscola Series

The Tuscola series consists of moderately well drained soils that occur on uplands and lake plains. These soils developed in stratified loamy material.

In a typical profile, the surface layer consists of dark-brown to brown fine sandy loam and is about 8 inches thick. Below this is a 3-inch subsurface layer of brown fine sandy loam. The subsoil is about 25 inches thick. It is made up of 8 inches of yellowish-brown, friable loam; 11 inches of yellowish-brown, mottled, firm, stratified light silty clay loam; and 6 inches of pale-brown, mottled, friable, stratified silt loam. The underlying material, at a depth of 36 inches, is very pale brown, mottled silt that is stratified with sand and very fine sand. This material extends to a depth of at least 60 inches.

Fertility is medium, the available water capacity is high, permeability is moderately slow, and runoff is slow to medium. There are some wet spots that need drainage. Erosion and soil blowing are hazards if crops are grown.

Most areas of Tuscola soils have been cleared and are cultivated. Some areas are used for hay and pasture, and some are wooded. The native vegetation is a mixture of hardwoods, including maple, oak, beech, and hickory.

Typical profile of Tuscola fine sandy loam, 2 to 6 percent slopes, cultivated, located in the SE¼NE¼SE¼ sec. 18, T. 5 N., R. 13 W. (Jamestown Township):

Ap—0 to 8 inches, dark-brown to brown (10YR 4/3) fine sandy loam; weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

A2—8 to 11 inches, brown (10YR 5/3) fine sandy loam; weak, thick, platy structure; friable; strongly acid; clear, wavy boundary.

B21t—11 to 19 inches, yellowish-brown (10YR 5/4) loam to silt loam; weak, medium, subangular blocky structure; friable; strongly acid; clear, wavy boundary.

B22t—19 to 30 inches, yellowish-brown (10YR 5/6–5/8) light silty clay loam; few, fine, faint, pale-brown (10YR 6/3) mottles; moderate, medium, subangular blocky structure; firm; very strongly acid; clear, wavy boundary.

B23—30 to 36 inches, pale-brown (10YR 6/3) silt loam; common, medium, faint, very pale brown (10YR 7/3) mottles; weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C—36 to 60 inches, very pale brown (10YR 7/3) silt stratified with thin layers of sand and very fine sand; many, medium, distinct, brownish-yellow (10YR 6/6) mottles; massive; friable; moderately alkaline.

The solum is 30 to 46 inches or more in thickness. In reaction it ranges from neutral to very strongly acid.

The color of the Ap horizon ranges to dark grayish brown (10YR 4/2) or brown (10YR 5/3). That of the A2 horizon ranges to grayish brown (10YR 5/2).

The texture of the B horizon is fine sandy loam, loam, silt loam, or light silty clay loam. The B22t and B23 horizons are mottled below a depth of 20 inches.

Tuscola soils occur near Miami, Nester, and Morley soils, all of which lack the stratification that characterizes the C horizon and the lower part of the B horizon of Tuscola soils. Tuscola soils formed in the same kind of material as Kibbie soils, but they are better drained than Kibbie soils and have pale-brown mottles instead of gray mottles in the B2 horizon.

Tuscola fine sandy loam, 2 to 6 percent slopes (TsB).—This soil occupies ridges and knolls on uplands and lake plains. The slopes are generally short, and the areas are small.

In some places the surface and subsurface layers have been removed by erosion and yellowish-brown loam or silt loam is now at the surface. Included in mapping were spots of Kibbie soils, which are less well drained than Tuscola soils; spots in which the underlying material is dominated by layers of silty clay; and areas in which the slope is slightly more than 6 percent and the lower part of the subsoil is not mottled.

Fertility is medium, the available water capacity is high, and permeability is moderately slow. The soil is wet early in spring, and some spots need artifiicial drainage. Water erosion and soil blowing are hazards if crops are grown.

The use of this soil is governed by the use of the surrounding soils. Most areas are within cultivated fields. (Capability unit IIe-2 (2.5a); woodland suitability group K)

Ubly Series

The Ubly series consists of well drained and moderately well drained soils that occur on till plains and moraines. These soils are underlain with clay loam at a depth of 18 to 40 inches.

In a typical profile, the surface layer consists of dark-

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brown sandy loam and is about 8 inches thick. The uppermost 4 inches of the subsoil is dark-brown, friable sandy loam. Below this is a 9-inch layer of light brownish-gray, very friable loamy fine sand and a 7-inch layer of dark yellowish-brown, firm sandy clay loam. The underlying material, at a depth of about 38 inches, is dark-brown, limy clay loam; it extends downward several feet.

Fertility is medium, and the available water capacity is moderate. A shortage of moisture during the latter part of summer is likely. Permeability is moderate in the upper layers and moderately slow in the underlying material. Runoff is slow to rapid, depending on the slope. The organic-matter content is low. Erosion and soil blowing are hazards if crops are grown.

Ubly soils are suited to most crops. Some of the acreage is cropland, some is pasture, and some is woodland. The native vegetation consists mainly of upland hardwoods, including hard maple, beech, ash, oak, and some hickory; it also contains some white pine.

Typical profile of Ubly sandy loam, 2 to 6 percent slopes, cultivated and eroded, located in the SE¼NE¼NE¼ sec. 11, T. 9 N., R. 13 W. (Chester Township):

Ap—0 to 8 inches, dark-brown (10YR 3/3) sandy loam; weak, medium, granular structure; very friable; slightly acid; abrupt, smooth boundary.

Bir—8 to 12 inches, dark-brown (7.5YR 4/4) sandy loam; weak, medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

A'2—12 to 21 inches, light brownish-gray (10YR 6/2) loamy fine sand; weak, medium, subangular blocky structure; very friable; slightly acid; clear, irregular boundary.

IIB't—21 to 38 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; moderate, medium, subangular blocky structure; firm; medium acid; gradual, wavy boundary.

IIC—38 to 60 inches, dark-brown (7.5YR 4/4) clay loam; moderate, medium, subangular blocky structure; firm; calcareous.

The depth to the IIB't horizon ranges from 18 to 40 inches, and the depth to the calcareous IIC horizon from 30 to 50 inches.

In undisturbed areas the profile has a 1- to 3-inch A1 and a 3- to 6-inch A2 horizon instead of an Ap. The color of the A1 horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). The color of the A2 horizon is light gray (10YR 6/1), light brownish gray (10YR 6/2), or gray (10YR 5/1), and the texture is loamy sand or loamy fine sand.

The color of the Ap horizon ranges to very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2).

The color of the Bir horizon ranges to reddish brown (5YR 4/4), and that of the A'2 to pale brown (10YR 6/3). In some profiles A'2 material occurs only as thick coatings on peds and as fillings in cracks and root channels in the upper part of the IIB't horizon. The color of the IIB't horizon ranges to dark brown (7.5YR 4/4), and the texture to clay loam or silty clay loam. Where drainage is only moderately good, the profile is mottled below a depth of about 16 inches.

In the IIC horizon, the color ranges to brown (10YR 5/3), light brownish gray (10YR 6/2), or dark yellowish brown (10YR 4/4). The texture of this horizon is clay loam or silty clay loam.

Ubly soils occur near Nester and Menominee soils. They are coarser textured in the upper part of the solum than Nester soils and finer textured in the Bir horizon than Menominee soils. Ubly soils formed in the same kind of material as Owosso soils. They have a Bir horizon, which Owosso soils lack.

Ubly sandy loam, 0 to 2 percent slopes (UlA).—This soil occupies ridgetops on uplands.

In most areas this soil is only moderately well drained and is mottled below a depth of 16 to 18 inches. The subsurface layer and the uppermost layer of the subsoil are thicker than those in the profile described. In some areas the lowest layer of the subsoil is gravelly, and in some a thin layer of gravel occurs in the uppermost 18 to 40 inches of the profile. There are small areas in which the texture to a depth of more than 40 inches is dominantly sandy loam. Included in mapping were spots of Nester soils, which have a surface layer of loam, and of Belding and Kawkawlin soils, which are in depressions and drainageways and are less well drained than Ubly soils.

Fertility is medium, and the available water capacity is moderate. Permeability is moderate in the upper layers and moderately slow in the underlying material. Runoff is slow. Small wet spots need drainage. The moisture supply is deficient after prolonged periods of dry weather.

Most of the acreage is cropland. Corn, small grain, and hay are the common crops. A few small areas are still wooded. (Capability unit IIs–2 (3/2a); woodland suitability group A)

Ubly sandy loam, 2 to 6 percent slopes (UlB).—This soil occupies hillsides and hilltops on uplands.

This soil has the profile described as typical of the series. In areas that have never been cultivated, the profile generally has a 3- to 5-inch surface layer of very dark gray sandy loam and a 4- to 6-inch subsurface layer of gray sandy loam. In such areas the uppermost layer of the subsoil is thicker than that in the profile described. Some cultivated areas still have a thin subsurface layer. In many areas the soil is mottled at a depth of 18 or more inches. Where the soil is eroded, the limy underlying material is nearer the surface. In some places the subsoil is gravelly, and in other places the texture to a depth of more than 40 inches is sandy loam. Included in mapping were spots of Menominee soils in which the texture is sand or loamy sand to a depth of 18 to 40 inches; spots of Nester soils, which have a finer textured surface layer; and spots of Belding and Kawkawlin soils, which are in depressions and drainageways and are less well drained than Ubly soils. Other inclusions are areas that have slopes of less than 2 percent or more than 6 percent.

Fertility is medium, and the available water capacity is moderate. Permeability is moderate in the upper layers and moderately slow in the underlying material. Runoff is medium. Erosion is a hazard if crops are grown. A shortage of moisture during the latter part of the summer retards plant growth.

This soil is suited to the common crops, and most of it is cropland. (Capability unit IIe–3 (3/2a); woodland suitability group A)

Ubly sandy loam, 6 to 12 percent slopes (UlC).—This soil occupies hillsides on uplands.

In most areas of this soil, the horizons are thinner than those in the profile described, and the limy underlying material is generally within 36 inches of the surface. In a few spots that are severely eroded, the depth to the limy underlying material is less than 18 inches. In other areas the texture is sandy loam to a depth of more than 42 inches. The subsoil in some places is gravelly. Included in mapping were spots of Nester soils, which are finer textured throughout; spots of Menominee soils, which are coarser textured; and spots of Belding and Kawkawlin soils, which are in depressions and drainageways and are less well drained than Ubly soils.

Fertility is medium, and the available water capacity is moderate. Permeability is moderate in the upper layers and moderately slow in the underlying material. Runoff is rapid. Erosion is a hazard if crops are grown. The moisture supply is deficient after prolonged periods of dry weather.

Nearly all areas of this soil are used for crops, commonly corn, small grain, and hay. Cropping systems are relatively long and include a high proportion of small grain and hay. Some areas are used only for hay or pasture. (Capability unit IIIe–5 (3/2a); woodland suitability group A)

Wallkill Series

The Wallkill series consists of poorly drained soils that occur on flood plains, mainly at the outer edge next to the uplands, and also on uplands, where they occupy closed potholes and spots at the edge of organic deposits. These soils formed in recent deposits of loamy material underlain at a depth of 10 to 40 inches with buried deposits of organic material.

In a typical profile, the surface layer consists of greenish-gray silt loam and is about 6 inches thick. Immediately below this is an 18-inch layer of dark greenish-gray, mottled light silty clay loam. This is underlain with organic deposits several feet thick. The uppermost 6 inches of organic material is black, mottled muck mixed with mineral soil; the next 10 inches is black, mottled muck that contains particles of wood; and the rest, below a depth of 40 inches, is a mixture of dark reddish-brown peat and black muck.

Fertility is high, and the available water capacity is high. Permeability is moderate in the mineral layers and rapid in the organic layers. Runoff is very slow to ponded. Drainage is needed, and frost damage to crops is a hazard. These soils are subject to flooding. They are unstable and will not support heavy loads.

Areas that have been drained and are not frequently flooded or ponded have been cleared and are cultivated. Many areas are idle, and many are still wooded. The native vegetation consists of elm, ash, red maple, silver maple, and some northern white-cedar. Trees grow slowly and are shallow rooted.

Typical profile of Wallkill silt loam, undisturbed, located in the SW¼NW¼SW¼ sec. 2, T. 9 N., R. 13 W. (Chester Township):

A1—0 to 6 inches, greenish-gray (5GY 5/1) silt loam; many, medium, faint, gray (5Y 5/1) mottles; massive; friable; neutral; clear, irregular boundary.

Cg—6 to 24 inches, dark greenish-gray (5GY 4/1) light silty clay loam; many, medium, faint, greenish-gray (5GY 5/1) and few, medium, prominent, dark-brown (7.5YR 4/4) mottles; massive, parting to moderate, medium, granular structure; firm; nonplastic when wet; neutral; gradual, wavy boundary.

IIIb—24 to 30 inches, black (N 2/0), well-decomposed muck mixed with mineral soil; few, medium, distinct, dark greenish-gray (5GY 4/1) mottles; moderate, medium, granular structure; friable; neutral; clear, wavy boundary.

IIIb—30 to 40 inches, black (N 2/0), well-decomposed muck; few, medium, distinct, dark reddish-brown (5YR 3/4) mottles around scattered wood particles; moderate, medium, granular structure; friable; neutral; clear, wavy boundary.

IIIb—40 to 60 inches, dark reddish-brown (5YR 3/2) peat and black (N 2/0) muck; moderate, medium, granular structure, grading to massive at a depth of 48 inches; friable; neutral.

The thickness of the mineral layers is commonly between 18 and 30 inches but ranges from 10 to about 40 inches.

The color of both the A1 and the Cg horizons ranges to grayish brown (10YR 5/2), brown (10YR 5/3), or dark grayish brown (10YR 4/2). The texture of these horizons is loam, silt loam, light silty clay loam, or light clay loam. Strata of sandy loam occur in the Cg horizon in some places.

In some places the IIIb horizon consists of peat.

Wallkill soils occur near Carlisle, Houghton, Cohoctah, and Sloan soils. Wallkill soils are made up of 10 to 40 inches of mineral soil over several feet of organic material. Carlisle and Houghton soils consist of organic material throughout, and Cohoctah and Sloan soils of mineral material.

Wallkill silt loam (0 to 3 percent slopes) (Wa).—This nearly level to depressional soil occurs on flood plains, in closed depressions on uplands, and at the edges of areas of organic soils, where these soils merge with mineral soils of the uplands. Most areas are long and narrow in shape and of small extent.

In some areas of this soil in Georgetown Township, the uppermost 18 to 24 inches of the profile is alluvium of silt loam texture; below the alluvium is a foot or two of organic material, and below that, marl. In other places the layers below a depth of 2 or 3 feet consist of thin strata of organic material and mineral material rather than entirely of organic material. Included in mapping were scattered spots of Washtenaw soils, which have a sandy overwash, and of Carlisle and Houghton soils, which consist entirely of organic material.

Fertility is high, and the available water capacity is high. Permeability is moderate in the mineral layers and rapid in the organic layers. Runoff is very slow to ponded. Crops are likely to be damaged by frost. Deposition of additional overwash is a hazard. Drainage is needed.

Areas that are adequately drained are cultivated. Corn is the chief row crop. Many areas cannot be drained artificially and are used for pasture or are covered with trees or brush. Limitations for construction are severe. (Capability unit IIIw–15 (L–2c); woodland suitability group U)

Warners Series

The Warners series consists of very poorly drained organic soils that occur in ponded areas along the outer margin of flood plains and also in pockets on upland hillsides.

In a typical profile, the surface layer consists of well-decomposed muck and is only about 5 inches thick. Directly below the organic material is a 7-inch layer of grayish-brown, limy marl streaked with black. At a depth of 12 inches is light-gray, mottled, limy marl; it extends downward several feet.

Fertility is low, and the available water capacity is high. Runoff is slow to ponded. Permeability is rapid in the organic layer and variable in the marl. The water table is high, and drainage is needed. Frost damage to crops is a hazard.

These soils are suited to only a few kinds of crops. A few areas are cultivated, but most are in pasture or woodland. The native vegetation is a mixture of lowland hardwoods and conifers, including elm, ash, cottonwood, red maple, and northern white-cedar. Trees grow slowly and

are shallow rooted and of low quality. Limitations for construction are severe.

Typical profile of Warners muck, undisturbed, located in the NW¼SE¼SE¼ sec. 28, T. 5 N., R. 13 W. (Jamestown Township):

1—0 to 5 inches, black (N 2/0), well-decomposed muck; moderate, fine, granular structure; friable; moderately alkaline; abrupt, wavy boundary.

IIC1—5 to 12 inches, grayish-brown (2.5Y 5/2) marl; few, fine, distinct, vertical streaks of black (N 2/0), ¼ inch thick; massive; friable; calcareous; gradual, wavy boundary.

IIC2—12 to 60 inches, light-gray (5YR 7/1) marl; few, medium, prominent, reddish-brown (5YR 5/3) mottles; massive; calcareous.

The texture of the surface layer ranges to loam or silt loam. The reaction of this layer is mildly or moderately alkaline.

The calcium content of the marl ranges from 20 percent to 70 percent or more.

Warners soils are similar to Edwards soils but have a much thinner deposit of organic material.

Warners muck (0 to 2 percent slopes) (Wm).—This soil occurs on flood plains, mainly along the outer margins, and in pockets on uplands.

In some areas the surface layer is black silt loam that is high in organic-matter content. In other places the surface layer consists mostly of grayish marl. In Georgetown Township, and especially near the village of Hudsonville, the underlying marl is only 12 to 36 inches thick and is underlain with calcareous sand and gravel. The surface layer in some areas is strongly acid. Included in mapping were spots of Edwards soils, which have a thicker deposit of organic material.

Fertility is low, and the available water capacity is high. Runoff is slow to ponded. Permeability is rapid in the organic layer and variable in the marl. Draining this soil is very difficult. Tilth deteriorates readily, and frost damage to crops is a hazard.

This soil is better suited to trees and pasture plants than to cultivated crops. Limitations for construction are severe. (Capability unit IVw–6 (M/mc); woodland suitability group U)

Wasepi Series

The Wasepi series consists of somewhat poorly drained soils that occur on low terraces, on outwash plains, and in drainageways in the southeastern part of the county. These soils developed in 24 to 40 inches of sandy loam or loamy sand over limy sand and gravel.

In a typical profile, the surface layer consists of very dark brown sandy loam and is about 8 inches thick. Below this is a 4-inch subsurface layer of dark grayish-brown sandy loam. The subsoil is about 21 inches thick. It is made up of 3 inches of light olive-brown, mottled, friable sandy loam; 11 inches of yellowish-brown, mottled, friable heavy sandy loam; and 7 inches of light yellowish-brown, mottled, very friable gravelly loamy sand. The underlying material, at a depth of 33 inches, is light brownish-gray, limy sand and gravel.

Fertility is medium, and the available water capacity is low. Permeability is moderate in the upper layers and rapid in the underlying material. Runoff is slow to very slow. The water table fluctuates; it is within 2 feet of the surface during prolonged periods of wet weather and recedes during dry weather. Drainage is needed. Blowing is a hazard when the soils are dry. Frost damage to crops is a slight hazard.

Most areas of Wasepi soils have been cleared and are cultivated. Corn, small grain, and hay are the common crops. Some areas are used only for hay and pasture. A few areas are still wooded. The native vegetation is a mixture of lowland hardwoods, including elm, ash, maple, and some oak.

Typical profile of Wasepi sandy loam, cultivated, located in the N½SE¼SE¼NE¼ sec. 9, T. 6 N., R. 13 W. (Georgetown Township, 0.2 mile N. of Bauer Rd. on 24th St.):

Ap—0 to 8 inches, very dark brown (10YR 2/2) sandy loam; weak, medium, granular structure; friable; neutral; abrupt, smooth boundary.

A2—8 to 12 inches, dark grayish-brown (10YR 4/2) sandy loam; very weak, medium, subangular blocky structure; friable; contains pebbles 1 inch in diameter; slightly acid; clear, wavy boundary.

B21t—12 to 15 inches, light olive-brown (2.5Y 5/6) sandy loam; many, medium, distinct, dark grayish-brown (10YR 4/2) mottles; weak, medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

B22t—15 to 26 inches, yellowish-brown (10YR 5/4) heavy sandy loam; many, medium, distinct, light brownish-gray (10YR 6/2) mottles; weak, fine, subangular blocky structure; friable; contains much pea-sized gravel; mildly alkaline; clear, wavy boundary.

B3—26 to 33 inches, light yellowish-brown (10YR 6/4) gravelly loamy sand; many, fine, distinct, dark grayish-brown (10YR 4/2) mottles; weak, fine, subangular blocky structure; very friable; mildly alkaline; clear, wavy boundary.

C—33 to 50 inches, light brownish-gray (10YR 6/2) sand and gravel; single grain; loose; calcareous.

The solum is 24 to 40 inches thick. In reaction it ranges from medium acid to mildly alkaline. It contains varying amounts of gravel and, in some places, numerous cobblestones.

In undisturbed areas there is a 3-inch to 6-inch A1 horizon of very dark gray (10YR 3/1) to very dark brown (10YR 2/2) sandy loam or loamy sand.

The color of the Ap horizon ranges to dark brown (10YR 3/3), and the texture is sandy loam or loamy sand. The A2 horizon ranges to pale brown (10YR 6/3) in color and is mottled in places.

In the B21t and B22t horizons, the color ranges to yellowish brown (10YR 5/8) or dark yellowish brown (10YR 3/4), and the mottles generally have a chroma of 2 or less. The texture of these horizons is sandy loam, heavy sandy loam, clay loam, or gravelly clay loam. Where the texture is clay loam, the horizon is less than 10 inches thick.

In the C horizon, the color has a hue of 10YR, a value of 5 or more, and a chroma of 4 or less. Generally this horizon consists of stratified sand and gravel, but in some places it is mostly sand and in others it is mostly gravel.

Wasepi soils occur near Matherton and Gilford soils. They have a coarser textured B2t horizon than Matherton soils and a slightly finer textured B2t horizon than Gilford soils, which are more poorly drained than Wasepi soils. Wasepi soils formed in the same kind of material as Gladwin soils, but they lack the Bir horizon that is characteristic of Gladwin soils.

Wasepi sandy loam, 0 to 2 percent slopes (WsA).—This soil occurs on outwash plains, on low terraces, and in drainageways in the southeastern part of the county. Associated with it are Matherton, Gilford, and Lacota soils.

In some areas the surface layer is very dark gray silt loam or loamy sand; in others it is very dark gray sandy loam. In some places the surface layer has a reddish hue

and 3- to 5-inch cobblestones are to be found throughout the profile. Included in mapping were spots of Gilford and Lacota soils, which are more poorly drained than Wasepi soils; spots in which the surface layer is limy; and spots in which limy gravel is just below the surface layer.

Fertility is medium, and the available water capacity is low. The water table fluctuates, so the soil is wet at some times and dry at others. Soil blowing is a hazard during the dry summer months. Frost damage to crops is a slight hazard.

This soil is suited to crops, and most areas have been cleared and are cultivated. Corn, small grain, and hay are the common crops. Specialty crops, including vegetables, melons, and pickling cucumbers, are grown in a few areas. (Capability unit IIIw–5 (4b); woodland suitability group G)

Washtenaw Series

The Washtenaw series consists of poorly drained soils that occur on uplands in closed or nearly closed pockets, potholes, basins, waterways, and depressions. These soils formed in 10 to 40 inches of loamy material deposited over mineral soils of various textures.

In a typical profile, the surface layer consists of dark grayish-brown loam and is about 8 inches thick. Below this is an 11-inch layer of very dark grayish-brown loam and then an 8-inch layer of dark-gray loam. At a depth of 27 inches is a buried surface layer of very dark brown silt loam, and at a depth of 35 inches, a buried subsoil of gray, mottled clay loam that extends to a depth of more than 50 inches.

Fertility is medium to high, and the available water capacity is high. Permeability is moderate to slow, depending on the texture of the buried soil. Runoff is very slow to ponded. The water table is high, and drainage is needed if crops are to be grown. Many areas lack adequate outlets for drainage. Frost damage to crops is a hazard.

If drained Washtenaw soils are suited to most crops. Most undrained areas are used for pasture, but some are wooded. The native vegetation is a mixture of lowland hardwoods and brush, including elm, maple, ash, buttonbush, poison sumac, willow, and dogwood.

Typical profile of Washtenaw loam, cultivated, located in the NE¼SW¼SW¼SE¼ sec. 26, T. 8 N., R. 15 W. (Crockery Township, 1,980 ft. E. of 104th Ave. and 660 ft. N. of Garfield St., in a pasture):

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

A1—8 to 19 inches, very dark grayish-brown (10YR 3/2) loam; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

Cg—19 to 27 inches, dark-gray (10YR 4/1) loam; weak, medium and coarse, subangular blocky structure; friable; organic stains of very dark gray (10YR 3/1) on ped faces; neutral; abrupt, wavy boundary.

A1b—27 to 35 inches, very dark brown (10YR 2/2) silt loam; moderate, medium, subangular blocky structure; friable to firm; neutral; clear, wavy boundary.

Bgb—35 to 50 inches, gray (5Y 5/1) clay loam; few, fine, prominent, yellowish-brown (10YR 5/6) mottles; moderate, medium, angular blocky structure; firm; mildly alkaline.

The reaction of the solum ranges from medium acid to mildly alkaline.

The color of the Ap horizon ranges to grayish brown (10YR 5/2), brown (10YR 5/3), or dark gray (10YR 4/1).

In the Cg horizon the color ranges to gray (10YR 5/1–6/1), and the texture is silt loam, loam, or sandy loam.

The texture of the A1b horizon is clay loam, loam, sandy loam, or silt loam, and that of the Bgb horizon is clay loam or sandy loam. In some profiles the material below a depth of 40 inches is coarse textured.

Mottles that have a chroma of 2 or less occur below the Ap horizon in some areas.

Washtenaw soils occur near Kawkawlin, Blount, Sims, and Hettinger soils. The associated soils lack the recent overwash that is characteristic of Washtenaw soils. Washtenaw soils resemble Wallkill soils in having a loamy overwash, but in Wallkill soils the buried layers consist of organic rather than mineral material.

Washtenaw loam (0 to 4 percent slopes) (Wt).—This soil occurs throughout the county in small depressions that lack outlets for surface water, on lower slopes, in waterways, and in other places where soil material washed from higher areas can accumulate. Associated with it are Kawkawlin, Blount, and Sims soils. Most of the areas are long and narrow in shape and of small extent. Areas in closed depressions are circular.

The texture of the upper layers is generally similar to that of the surface layer of adjacent soils. It is commonly loam, silt loam, or sandy loam. The lower layers are of various textures. Included in mapping were spots in which the loamy overwash is more than 42 inches thick and also spots that lack the overwash. In the depressions that have no outlets are spots in which the surface layer is muck or peat.

Fertility is medium to high, and the available water capacity is high. Permeability is moderate to slow, and runoff is very slow to ponded. The water table is high. Many areas lack drainage outlets. Frost damage to crops is a hazard.

Some areas of this soil are drained and cultivated. The closed depressions are idle or are used for pasture. (Capability unit IIIw–12 (L–2c); woodland suitability group P)

Wind Eroded Land, Sloping

Wind eroded land, sloping (WuC), consists of sandy soils, mainly of the Croswell and Au Gres series, that have been severely damaged by soil blowing. All or nearly all of the original surface layer and subsoil is gone. The present surface layer is loose, light-colored sand that is low in organic-matter content. Most areas include some blowouts and some small, low, dune shaped knolls. Chunks of a dark reddish-brown hardpan are on the surface in some areas. The slope range is 6 to 12 percent.

Fertility is very low, and the available water capacity is very low. The water table fluctates and is within 24 inches of the surface in spring. Areas unprotected by vegetation are subject to further damage by soil blowing during the dry summer months. In spring, when the soil material is kept moist by the high water table, the hazard of blowing is slight.

Some areas of this unit were cultivated in the past. Nearly all were burned over at one time or another. Some have been stabilized and reforested. Others are now idle and have little vegetation. All of the acreage ought to be stabilized and planted to trees or grass. (Capability unit VIIIs–1 (Sa); woodland suitability group Y)

Use and Management of the Soils

This section begins with an explanation of the system of capability grouping used in the Soil Conservation Service to classify soils according to their relative suitability for general field crops. Following this explanation are discussions of the use and management of the soils of Ottawa County, as grouped according to this system. Next is a table in which are shown predicted yields of the principal crops grown in the county, by individual soils. This is followed by discussions of the use and management of the soils as woodland; for this purpose, the soils are grouped on the basis of similarity in productivity and management needs. Then comes a table that shows the relative suitability of individual soils for the elements of wildlife habitat and for three kinds of wildlife. The next part of the section concerns soils in connection with engineering; it consists mainly of tables that give descriptions of soil properties significant in engineering and interpretations of these properties as they affect the suitability of the soils for specified engineering uses. The last part of the section discusses soil properties in relation to town and country planning.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show the suitability and limitations of groups of soils for forest trees or for engineering.

In the capability system, all kinds of soils are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. (No soils in Ottawa County are in class I.)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife. (No soils in Ottawa County are in class V.)

Class VI soils have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture, range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuitable for cultivation and limit their use largely to pasture, range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in some parts of the United States but not in Ottawa County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–3 or IIIe–5. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral specifically identifies the capability unit within each subclass.

Management by capability units[2]

In the following pages the capability units in Ottawa County are described and suggestions for use and management are given. The Arabic numerals that identify the units are not consecutive, because not all the units in the statewide classification are represented in Ottawa County. The name of each series represented is mentioned in the description of each unit, but this does not necessarily mean that all the soils of a given series are in that particular unit. The "Guide to Mapping Units," at the back of this publication, gives the names of the individual mapping units and the capability classification of each. The symbols in parentheses following each capability unit designa-

[2] By William Allred, Richard Drullinger, and Warren Studley, Soil Conservation Service.

tion refer to the management groups in the Michigan State system of classification (*5*).

CAPABILITY UNIT IIe-1 (1.5a)

This unit consists of well drained to moderately well drained soils of the Morley and Nester series. Both the subsoil and the underlying material of these soils are moderately fine textured. Most areas are slightly eroded. The slope range is 2 to 6 percent.

The available water capacity is high, and fertility is high. The organic-matter content is moderately low. Runoff is medium, and permeability is moderately slow. These soils warm up rather slowly in spring, and they lose their good tilth and become hard and cloddy if tilled when wet. The moderately fine textured subsoil is difficult to work if it is exposed as a result of erosion.

Controlling erosion, maintaining good tilth, and supplying organic matter are the major management needs. Terracing and contour stripcropping for control of erosion are difficult in some areas because of short, complex slopes. Cover crops, additional crops of grasses and legumes in the cropping system, and careful tillage are needed to control erosion where terracing and stripcropping are not practical. Fall plowing permits earlier planting in the following spring, but it also increases the hazard of erosion. Scattered wet spots delay planting and harvesting unless drained artificially.

Wheat, hay, and corn are the main crops grown on these soils.

CAPABILITY UNIT IIe-2 (2.5a)

This unit consists of moderately well drained to well drained soils of the Miami and Tuscola series. These soils have a medium-textured to moderately fine textured subsoil and medium-textured underlying material. Most areas are slightly eroded; a few are moderately eroded. The slope range is 2 to 6 percent, and the slopes in some areas are short and complex.

The available water capacity is high, and fertility is medium. The organic-matter content is moderately low. Runoff is medium to slow, and permeability is moderate to moderately slow. Small seep spots and wet depressions hinder planting and harvesting in wet years.

Controlling erosion, maintaining good tilth, and maintaining fertility are the major management needs. Terracing and stripcropping for control of erosion are difficult where the slopes are short and complex. Cover crops, careful tillage, and additional crops of grasses and legumes in the cropping system are needed to control erosion where terracing and stripcropping are not practical. Establishing grass in natural waterways reduces the hazard of gullying. Drying up wet spots by means of shallow surface drains permits tillage earlier in spring. Plowing under crop residues and green-manure crops adds organic matter and thereby improves the capacity to absorb water and reduces the likelihood of crusting. Applying manure helps to restore good tilth in the moderately eroded areas.

Corn, small grain, hay, and pasture are the common crops.

CAPABILITY UNIT IIe-3 (3a, 3/2a)

This unit consists of moderately well drained to well drained soils of the Hillsdale, Owosso, and Ubly series. These soils have a moderately coarse textured to moderately fine textured subsoil. The Hillsdale soil is underlain with moderately coarse textured material, and the Owosso and Ubly soils with moderately fine textured material. The slope range is 2 to 6 percent.

The available water capacity is only moderate; the moisture supply is not adequate to support the growth of crops during long periods of dry weather. Fertility is medium. The organic-matter content is moderately low. Runoff is slow to medium, and permeability is moderately slow to moderately rapid. These soils warm up and are ready for tillage early in spring, and they dry out quickly after rain. They are easy to till throughout a wide range in moisture content and are not likely to crust.

Controlling erosion, maintaining fertility, providing regular additions of organic matter, and conserving moisture are the major management needs. Terracing, stripcropping, and contour tillage are effective in controlling erosion. Minimum tillage helps to preserve good tilth and also to limit the erosion hazard. Winter cover crops provide organic matter and help to control erosion and soil blowing. Manure and crop residues improve tilth and increase the capacity to absorb water.

Corn, oats, wheat, hay, and potatoes are the common crops. Legumes and grasses suited to well-drained soils provide good yields of forage. Other suitable crops are fruits (except blueberries) and vegetables, both of which need soils that warm up early.

CAPABILITY UNIT IIw-2 (1.5b, 1.5c)

This unit consists of poorly drained to somewhat poorly drained soils of the Blount, Bowers, Hettinger, Kawkawlin, and Sims series. Both the subsoil and the underlying material of these soils are moderately fine textured. The slope range is 0 to 2 percent. Some areas are in shallow depressions.

The available water capacity is high, and fertility is high. The organic-matter content is moderate to high. Runoff is slow to ponded, and permeability is moderately slow. The water table is near the surface unless lowered by artificial drainage. These soils warm up and dry out slowly in spring unless drained. They puddle if tilled when wet, then dry out hard and cloddy. Planting, weeding, and harvesting are difficult because farm machinery is likely to bog down. Crops are damaged by frost in some years. Most areas include some wet depressions that can interfere with planting and cultivation.

Drainage and maintenance of good tilth are the major management needs. Reed canarygrass pasture is the only crop that can be grown without tile drainage. Tile drains are easily installed, and the trenches generally are stable, but many areas lack natural outlets for drainage. Diversion terraces to intercept runoff from higher areas are beneficial. Crop residues and green-manure crops improve tilth and workability. Plowing in fall permits earlier planting in the following spring and is less likely to damage tilth than plowing when the soils are wet in spring. After fall plowing the soils should be left in rough furrows through the winter and protected from erosion and blowing. Pastures should not be used when the soils are wet, because of the hazard of puddling.

Corn, small grain, and forage crops are the common crops. The selection of crops depends on the degree of drainage. Perennial grasses are grown in the wetter areas.

CAPABILITY UNIT IIw–3 (1.5b, 2.5b)

This unit consists of somewhat poorly drained soils of the Blount, Bowers, Conover, and Kawkawlin series. These soils have a moderately fine textured subsoil. The Conover soil has medium-textured underlying material, and the others, moderately fine textured. The slope range is 2 to 6 percent, and the topography is undulating.

The available water capacity is high, and fertility is high. The organic-matter content is moderate. Runoff is slow to ponded, and permeability is moderately slow to moderate. The water table is near the surface in spring. If tilled when wet the soils puddle and then dry out hard and cloddy and with a crust that hinders emergence of seedlings. Wet depressions cause delays in tillage and planting. Farm machinery bogs down in some areas in spring and after rain in other seasons.

Drainage and preservation of tilth are the major management needs. The soils are stable, and trenches and ditches, if properly constructed, need little maintenance. Drainage is difficult, nevertheless, because some areas lack outlets and the undulating topography makes it difficult to lay out complete drainage systems. Random tile and surface drains are used in some areas. Tilth can be improved and the tendency to crusting reduced by plowing under crop residues and green-manure crops. Minimum tillage helps to prevent deterioration of tilth.

Corn, small grain, and forage crops are grown in drained areas of these soils.

CAPABILITY UNIT IIw–6 (2.5b, 3b, 2.5c, 3c)

This unit consists of poorly drained to somewhat poorly drained soils of the Bruce, Kibbie, Lacota, Matherton, Richter, and Tonkey series. The Richter soil and the Tonkey soil have a moderately coarse textured to coarse textured subsoil; the others have a medium-textured to moderately fine textured subsoil. All have medium-textured to coarse-textured underlying material. The slope range is 0 to 2 percent.

The available water capacity is moderate to high, and fertility generally is medium. The organic-matter content is moderate to high. Runoff is slow, and water ponds in depressions. Permeability generally is moderate. These soils have a fluctuating high water table and are excessively wet in spring and after rain in other seasons. If drained artificially they dry out readily and are easy to work. Generally the moisture supply is adequate for crops. Deterioration of tilth is not a serious hazard.

Drainage is the major management need. Installing tile is difficult because the soil material is unstable and trenches cave in. Backfilling the trenches with organic material or surface soil helps to keep the drains free of soil; so does the use of special blinding material. Where the underlying material is sand, trenches should be dug during the driest part of the year.

Most of the common crops can be grown on drained areas of these soils. Small grain planted where drainage is poor is likely to grow rank and to lodge before it can be harvested.

CAPABILITY UNIT IIw–7 (2.5b, 3b)

This unit consists of somewhat poorly drained soils of the Kibbie and Richter series. The Kibbie soil has a medium-textured subsoil and medium-textured to coarse-textured underlying material. The Richter soil has a coarse textured to moderately coarse textured subsoil and moderately coarse textured underlying material. The slope range is 2 to 6 percent, and the topography is undulating.

The Kibbie soil has a high available water capacity, and the Richter soil a moderate available water capacity. Both have medium fertility, medium runoff, and moderate permeability. The organic-matter content is moderate. These soils have a fluctuating high water table and are excessively wet in spring and after rain in other seasons. If drained artificially they dry out readily and are easy to work. Generally the moisture supply is adequate for crops. Deterioration of tilth is not a serious hazard.

Drainage and erosion control are the major management needs. Undulating topography makes it difficult to install complete drainage systems. Areas that have outlets can be drained by means of random tile and surface drains. Tile trenches are likely to fill in with soil material. The Kibbie soil especially is unstable when wet, and trenches should be dug in this soil only during the driest part of the year. Special blinding of tile also helps to keep the lines free of soil material. Minimum tillage and the use of cover crops reduce the hazard of erosion. Plowing under green-manure crops and crop residues provides a regular supply of organic matter.

Most of the common crops can be grown on drained areas of these soils.

CAPABILITY UNIT IIw–8 (3/2b, 3/2c)

This unit consists of poorly drained to somewhat poorly drained soils of the Belding, Breckenridge, and Metamora series. These soils have a coarse-textured to moderately fine textured subsoil and moderately fine textured underlying material. The slope range is 0 to 6 percent. The Breckenridge soil is level to depressional.

The available water capacity is moderate, and fertility is medium. The organic-matter content is moderate. Runoff is slow to medium, and water ponds in depressions. Permeability is moderate to moderately rapid in the uppermost 18 to 40 inches and moderately slow in the lower part. The water table is near the surface in spring unless lowered by artificial drainage. In some years early planted or late-maturing crops in low areas are damaged by frost.

Drainage is the major management need. Both tile drains and surface drains are needed. The depth to and spacing of tile depend on the depth to the moderately fine textured layers. Pockets of sand occur in some areas, and the sand may fill in tile trenches. Tile should be installed when the soils are dry.

Most of the common crops can be grown in artificially drained areas of these soils.

CAPABILITY UNIT IIs–2 (3a, 3/2a)

This unit consists of moderately well drained to well drained soils of the Fox, Newaygo, and Ubly series. These soils have a moderately coarse textured to moderately fine textured subsoil. The Fox soil and the Newaygo soil are underlain with coarse-textured material, and the Ubly soil with moderately fine textured material. The slope range is 0 to 6 percent.

The available water capacity is moderate, and fertility is medium. The organic-matter content is moderately low. Runoff is slow. Permeability is generally moderate but is moderately slow below a depth of 18 to 40 inches in the Ubly soil. These soils warm up and are ready for tillage early in spring, and they dry out quickly after rain. They

are easy to till throughout a wide range in moisture content. They do not hold enough moisture to support crop growth through periods of dry weather. They are seldom excessively wet.

Conserving moisture, controlling erosion, maintaining fertility, and regularly supplying organic matter are the major management needs. Green-manure crops and crop residues add organic matter and thereby increase the capacity of the soils to absorb water. Terracing, stripcropping, and contour tillage are effective means of controlling erosion. Winter cover crops keep the soil from blowing and also provide organic matter. Minimum tillage reduces the hazard of erosion and also protects tilth and conserves organic matter.

Corn, oats, wheat, and hay are the common crops. Other suitable crops are fruits (except blueberries) and vegetables, both of which need soils that warm up early.

CAPABILITY UNIT IIIe-4 (1.5a)

This unit consists of moderately well drained to well drained soils of the Morley and Nester series. These soils have a moderately fine textured subsoil and moderately fine textured underlying material. The Nester soil is slightly eroded, and the Morley soil moderately eroded. The slope range is 6 to 12 percent, and the slopes generally are short and complex.

The available water capacity is high, and fertility is high. The organic-matter content is low. Permeability is moderately slow. Runoff is rapid, and the erosion hazard is severe. The moderately eroded Morley soil has poorer tilth and loses more water through runoff than the slightly eroded Nester soil. Both soils puddle readily if worked when wet. The surface crusts upon drying, and the crust results in uneven stands of plants. The effects of crusting are more severe on the Morley soil than on the Nester soil. Both soils include a few wet spots.

Controlling erosion, improving tilth, supplying organic matter regularly, and maintaining fertility are the major management needs. Because of the erosion hazard, cropping systems ought to consist largely of close-growing crops. Contour farming is possible in a few areas, but the short, complex slopes that characterize most areas make terracing and contour stripcropping difficult. Plowing under crop residues, applying lime and fertilizer, and growing cover crops and green-manure crops are effective ways of improving fertility and tilth and adding organic matter.

Corn, small grain, and hay are the common crops. Good pasture stands of legumes and grasses can be obtained if enough lime and enough fertilizer are used and grazing is managed carefully.

CAPABILITY UNIT IIIe-5 (2.5a, 3a, 3/2a)

This unit consists of moderately well drained to well drained soils of the Hillsdale, Miami, and Ubly series. These soils are moderately fine textured to moderately coarse textured in both the subsoil and the underlying material. The slope range is 6 to 12 percent.

The Hillsdale soil and the Ubly soil have a moderate available water capacity, and the Miami soil, a high available water capacity. All the soils have medium fertility and are moderately low in organic-matter content. Runoff is rapid in areas intensively farmed. The loss of water through runoff is greater where the soils are moderately eroded than where they are slightly eroded. Permeability is generally moderate but is moderately slow below a depth of 18 to 40 inches in the Ubly soil. Where only slightly eroded, the soils have good tilth and are easy to work; where moderately eroded, they have poor tilth and crust readily upon drying.

Controlling erosion and maintaining tilth and fertility are the major management needs. Cropping systems that include a large proportion of close-growing crops are needed to check runoff and control erosion. More intensive cropping systems can be used where the topography permits terracing and stripcropping. Minimum tillage is a help in maintaining good tilth and limiting the erosion hazard. Plowing under manure and green-manure crops improves tilth and increases the available water capacity.

If protected from erosion these soils are suited to most of the common crops. Good stands of pasture and forage plants can be obtained if enough lime and enough fertilizer are applied and grazing is managed carefully.

CAPABILITY UNIT IIIe-9 (4a, 4/2a)

This unit consists of moderately well drained to well drained soils of the Boyer, Mancelona, Menominee, Montcalm, Oshtemo, and Spinks series. These soils have a moderately fine textured to coarse-textured subsoil. The Menominee soil is underlain with moderately fine textured material, and the other soils with coarse-textured material. Most of the acreage is slightly eroded; a few areas are moderately eroded. The slope range is 6 to 12 percent.

The Menominee soil has a moderate water capacity, and the rest of the soils have a low avaliable water capacity. Fertility is generally low but is slightly higher in the Mancelona, Menominee, and Oshtemo soils than in the others. The organic-matter content is low. Runoff is medium. Permeability generally is moderately rapid or rapid but is moderately slow below a depth of 18 to 40 inches in the Menominee soil. All the soils warm up and are ready for planting early in spring. They are easy to till. If cultivated they are subject to both erosion and soil blowing. The organic-matter content is less and the available water capacity is lower where these soils are moderately eroded than where they are slightly eroded.

Controlling erosion and conserving moisture are the major management needs. Minimum tillage and stripcropping are effective in controlling erosion. Where stripcropping is difficult because of short, irregular slopes, the proportion of close-growing crops in the cropping system needs to be increased. Plowing under crop residues, green-manure crops, and barnyard manure provides a regular supply of organic matter and thereby improves both the available water capacity and the resistance to erosion.

Corn, small grain, and alfalfa are the main crops. Some fruits and vegetables are grown. Small grain is well suited because it matures early, while the supply of available water is still adequate. Shallow-rooted crops do not get enough moisture in dry years unless irrigated.

CAPABILITY UNIT IIIw-1 (1c)

This unit consists of Toledo silty clay loam, a poorly drained soil that has a fine textured subsoil and moderately fine textured to fine textured underlying material. The slope range is 0 to 2 percent.

The available water capacity is high, fertility is high, and the organic-matter content is high. Runoff is very

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slow, and water ponds in low areas. Permeability is slow. The water table is near the surface part of the year. The soil warms up slowly and so is not ready for tillage early in spring.

Drainage and maintenance of good tilth are the major management needs. Both tile and surface drains are needed. Special blinding material helps to promote the flow of water into the drains. Minimum tillage and frequent and liberal additions of organic matter help to maintain good tilth. Grazing of forage crops should be delayed till the soil is dry. In some places fall plowing permits earlier planting in the following spring.

Drained areas of this soil are suited to most of the common crops.

CAPABILITY UNIT IIIw–2 (1b)

This unit consists of somewhat poorly drained soils of the Selkirk series. These soils have a moderately fine textured to fine textured subsoil and fine textured underlying material. The slope range is 0 to 6 percent.

The available water capacity is moderate, and fertility is high. The organic-matter content is moderate. Runoff is slow, and permeability is slow. Water stands in depressions and low areas for long periods of time. The water table is high part of the year unless lowered by artificial drainage. The gently sloping areas are subject to erosion. Frost damage to crops is a hazard in some low areas.

Drainage and maintenance of good tilth are the major management needs. Tile drains, surface drains, and bedding systems are effective in removing excess water. Plowing in fall when the moisture content is favorable is less likely to damage the soil structure than spring plowing, and it also permits earlier planting. Adding organic matter improves permeability and thus promotes the flow of water into tile drains.

Drained areas of these soils are suited to the common crops.

CAPABILITY UNIT IIIw–5 (4b)

This unit consists of soils of the Gladwin and Wasepi series. These soils are somewhat poorly drained. They have a moderately coarse textured subsoil and coarse textured underlying material. The slope range is 0 to 6 percent, and the topography is undulating.

The available water capacity is low, and fertility is moderately low to medium. The organic-matter content is moderately low. Runoff is slow, and permeability is moderate. The water table is seasonally high unless lowered by artificial drainage. If drained the soils tend to become droughty in summer. Soil blowing is a hazard if large areas of the surface are exposed by tillage.

Drainage, maintenance of fertility, and conservation of moisture during periods of dry weather are the major management needs. Tile and surface drains remove excess water effectively. Complete drainage systems are not practical for some areas, because of undulating relief and lack of outlets. Random tile and ditches can be used to drain such areas. Because the soil material is unstable, trenches are likely to cave in. Installing tile is easiest when the soils are dry. Because these soils lose nutrients through leaching, frequent light applications of fertilizer are better than a single heavy application. Windbreaks, mulches, cover crops, minimum tillage, and stripcropping reduce the hazard of soil blowing.

CAPABILITY UNIT IIIw–6 (4c)

This unit consists of Gilford sandy loam, a very poorly drained to poorly drained, level soil that has a coarse textured to moderately coarse textured subsoil and coarse textured underlying material. The slope range is 0 to 6 percent.

The available water capacity is low, and fertility is medium. The organic-matter content is moderately low. Runoff is very slow, and water ponds in depressions and on flats. Permeability is moderate. The water table is high in spring; if it is lowered by artificial drainage, the soil tends to be droughty.

Drainage is the major management need. Tile and open ditches remove excess water effectively. Installing drainage systems is easiest when the soil is dry; ditchbanks and trenches cave in readily when the soil is wet. Windbreaks, mulches, cover crops, minimum tillage, and stripcropping help to control soil blowing.

Corn, small grain, and hay are the common crops. The choice of crops depends on the degree of drainage. Undrained areas are suitable for water-tolerant pasture plants and forage crops.

CAPABILITY UNIT IIIw–7 (4/1b)

This unit consists of Allendale sandy loam, 0 to 4 percent slopes, a somewhat poorly drained soil that has a coarse-textured to fine-textured subsoil and fine-textured underlying material.

The available water capacity is moderate, and fertility is medium. The organic-matter content is moderately low. Runoff is slow, and water ponds in the lowest spots during wet weather. Permeability is rapid in the upper layers and slow in the fine-textured lower layers. The water table is high in spring and after rain in other seasons. If it is lowered by artificial drainage, the soil dries out quickly and tends to become droughty. Soil blowing is a hazard if large areas of the surface are exposed by tillage.

Drainage and the conservation of moisture in periods of dry weather are the major management needs. Tile and open ditches remove excess water effectively. Installing drainage systems is easiest when the soil is dry; ditchbanks and trenches cave in readily when the soil is wet. The spacing of the tile lines depends on the depth to fine-textured material. The soil dries out more quickly if runoff from adjacent higher areas is diverted. Windbreaks and stripcropping help to control soil blowing. Plowing under crop residues and green-manure crops improves tilth and increases the available water capacity. Minimum tillage helps to conserve moisture.

The common field crops are grown on this soil. Small grain generally is better suited than corn, because it matures early while the moisture supply is still adequate. Early-maturing vegetables and small fruits can be grown in frost-free locations.

CAPABILITY UNIT IIIw–8 (4/1c, 3/2c)

This unit consists of poorly drained soils of the Pinconning and Breckenridge series. These soils have a coarse textured to moderately coarse textured subsoil and fine textured to moderately fine textured underlying material The slope range is 0 to 2 percent, and the topography is level to depressional.

The available water capacity is moderate, and fertility is low to medium. The organic-matter content is moderate-

ly low to moderate. Runoff is very slow to ponded. Permeability is moderate to moderately rapid in the upper 18 to 40 inches and slow to moderately slow in the lower part. The water table is high in spring and after rain in other seasons. If the water table is lowered by artificial drainage, the soils tend to become droughty. Frost damage to crops is a hazard. Large cultivated areas are subject to soil blowing.

Drainage is the major management need. Tile and open ditches drain most areas adequately. Some areas lack outlets for drainage. The soils in such areas dry out more quickly if runoff from higher areas is diverted. Stripcropping, mulches, cover crops, and windbreaks help to control soil blowing. Plowing under crop residues and green-manure crops improves fertility and increases the available water capacity. Irrigation reduces the frost hazard, in addition to providing water when needed.

If drained these soils are suited to most of the common crops. They are better suited to small grain than to corn. Vegetables and some small fruits can be grown, preferably under irrigation. The selection of pasture and forage crops depends on the degree of drainage.

CAPABILITY UNIT IIIw–9 (3/2b, 4/1b, 4/2b)

This unit consists of somewhat poorly drained soils of the Allendale, Belding, and Iosco series. These soils have a coarse-textured to fine textured subsoil and moderately fine textured to fine textured underlying material. The slope range is 0 to 6 percent.

The available water capacity is low to moderate, and fertility is low to medium. The organic-matter content is moderately low to moderate. Runoff is slow. Permeability is moderately rapid to rapid in the upper 18 to 40 inches and slow to moderately slow in the underlying material. The water table is high in spring and after rain in other seasons. If it is lowered by artificial drainage, the soils dry out quickly and tend to become droughty. Soil blowing is a hazard if large areas are cultivated.

Drainage and the conservation of moisture during periods of dry weather are the major management needs. Tile and open ditches drain most areas effectively. Drainage systems should be installed when the soils are dry, because trenches and ditchbanks cave in readily when the soils are wet. Some areas lack outlets for drainage. The soils in these areas dry out more quickly if runoff from adjacent higher areas is diverted. Stripcropping, minimum tillage, cover crops, and windbreaks help to control soil blowing. Plowing under crop residues and green-manure crops improves tilth and increases the available water capacity. Irrigation reduces the frost hazard, in addition to supplying water as needed.

These soils are suited to the common crops. Small grain does better than corn in dry years, because it matures early while the moisture supply is still adequate. Vegetables and small fruits can be grown under irrigation.

CAPABILITY UNIT IIIw–10 (4/2c)

This unit consists of Brevort sandy loam, a poorly drained soil that has a coarse-textured subsoil and moderately fine textured underlying material. The slope range is 0 to 2 percent, and the topography is level to depressional.

The available water capacity is moderate, and fertility is low. The organic-matter content is moderately low. Runoff is very slow to ponded. Permeability is rapid in the upper layers and moderately slow in the moderately fine textured underlying material. The water table is high. Unless the water table is lowered by artificial drainage, the soil dries out slowly in spring. If drained it dries out quickly and tends to become droughty. Crops are damaged by frost in some years.

Drainage is the major management need. Tile and open ditches drain some areas adequately. Drainage systems should be installed when the soil is dry, because ditchbanks and trenches cave in readily when the soil is wet. The depth to and spacing of tile drains depend on the depth to the moderately fine textured underlying material. Some areas lack outlets for drainage. Windbreaks, stripcropping, cover crops, and mulches help to control soil blowing. Adding organic matter increases the available water capacity.

If drained this soil is fairly well suited to crops and pasture. Many areas are not used for farming.

CAPABILITY UNIT IIIw–11 (5c)

This unit consists of very poorly drained to poorly drained soils of the Granby series. These soils are coarse textured in both the subsoil and the underlying material. The slope range is 0 to 2 percent.

The available water capacity is low, and fertility is low. The organic-matter content is high. Runoff is very slow, and water ponds in depressions. Permeability is rapid if the naturally high water table is lowered by artificial drainage. After the water table is lowered, the soils tend to become droughty. Soil blowing is a hazard if large areas are cultivated.

Drainage, conservation of moisture and fertility after drainage, and control of soil blowing are the major management needs. Tile and open ditches provide effective drainage. Drainage systems should be installed when the soils are dry, because trenches and ditchbanks are likely to cave in when the soils are wet. Depressions where water accumulates can be eliminated by leveling. Windbreaks, stripcropping, minimum tillage, cover crops, and mulches help to control soil blowing and to conserve moisture. In dry years crops may fail to mature; consequently, heavy applications of fertilizer are generally not practical.

Drained areas of these soils are suited to the common crops. In some places the soils are acid enough to be suited to blueberries.

CAPABILITY UNIT IIIw–12 (L–2c)

This unit consists of very poorly drained to somewhat poorly drained soils of the Ceresco, Cohoctah, Shoals, Sloan, and Washtenaw series. Both the subsoil and the underlying material of these soils are moderately coarse textured to moderately fine textured. The slope range is 0 to 6 percent. Many small areas are isolated by meandering streams.

The Ceresco soil has a moderate available water capacity and medium fertility and is moderate in organic-matter content; all the others in the unit have a high available water capacity and high fertility and are high in organic-matter content. Runoff is very slow to ponded. Permeability is moderate to moderately rapid in the Ceresco soil and the Cohoctah soil and moderately slow in all the others. The water table is high. Flooding early in the growing season is common. Frost damage to crops is a hazard.

Drainage and protection from flooding are the major management needs. Some areas lack outlets and so cannot be drained by means of tile and ditches. The likelihood of flood damage can be reduced by selecting row crops and forage crops that can be planted late, and the risk of frost damage can be reduced by selecting frost-hardy crops and planting only where air drainage is good. Minimum tillage and the utilization of crop residues are beneficial.

Areas that are drained and protected from flooding are well suited to the common crops. Other areas are suited to water-tolerant pasture plants and forage crops.

CAPABILITY UNIT IIIw–14 (L–4c)

This unit consists of very poorly drained to somewhat poorly drained soils of the Algansee and Glendora series. Both the subsoil and the underlying material are coarse textured. The slope range is 0 to 6 percent.

The available water capacity is low, and fertility is low. The organic-matter content is moderately low. Runoff is very slow to ponded, and permeability is rapid. Flooding is likely early in the growing season.

Drainage and protection from flooding are the main management needs. Drainage by means of tile and ditches is not practical for many areas, because of the instability of the soil material and a lack of outlets. The likelihood of flood damage can be reduced by selecting row crops and forage crops that can be planted late. Minimum tillage, fertilization, and return of crop residues are beneficial.

The suitability of these soils for crops varies; it depends on the frequency and severity of floods, the degree of drainage, and the severity of the frost hazard. Generally, the soils are better suited to water-tolerant forage crops of settling can be reduced by allowing the water table to

CAPABILITY UNIT IIIw–15 (L–2c, Mc, M/3c)

This unit consists of very poorly drained to poorly drained organic soils of the Carlisle, Linwood, and Wallkill series. In the Carlisle soil, the organic deposit is more than 42 inches thick. In the Linwood soil, it is 12 to 42 inches thick and is underlain with medium-textured mineral material. In the Wallkill soil, the organic deposit is covered with a 10- to 40-inch overburden of medium-textured mineral soil. The slope range is 0 to 6 percent, and the topography is level to depressional.

The soils in this unit have a high available water capacity. The Carlisle and Linwood soils are low in fertility, but the mineral overburden of the Wallkill soil is high in fertility. Runoff is very slow to ponded. The Carlisle soil is rapidly permeable; the upper, organic part of the Linwood soil is rapidly permeable, and the lower, mineral part is moderately permeable; the upper, mineral part of the Wallkill soil is moderately permeable, and the lower, organic part is rapidly permeable. The water table is high; it must be lowered by artificial drainage before crops can be grown. Soil blowing results in damage to growing crops as well as in loss of soil material. Windblown soil material fills in ditches and thereby impedes drainage.

Controlled drainage, protection from soil blowing, and improvement of fertility are the major management needs. Overdrainage should be avoided. A favorable level for the water table is one that allows crops to be grown and does not result in settling of the organic material, droughtiness, or an increase in the hazard of soil blowing. The danger of settling can be reduced by allowing the water table to rise closer to the surface when no crop is being grown. Some areas lack outlets for drainage. Compaction of the surface layer, sprinkler irrigation, stripcropping, and the use of buffer strips and windbreaks help to control soil blowing. Windbreaks provide cover for wildlife, besides helping to keep the soil from blowing. Selecting frost-hardy plants and planting where air drainage is good reduce the risk of frost damage. Fertilization is important because these organic soils are low in natural fertility, and the nutrient requirements of the common crops are high.

Drained areas of these soils are well suited to corn, vegetables, grass sod, and other specialty crops.

CAPABILITY UNIT IIIs–3 (4a)

This unit consists of moderately well drained to well drained soils of the Boyer, Mancelona, Montcalm, Oshtemo, and Spinks series. These soils have a moderately coarse textured to moderately fine textured subsoil and coarse textured underlying material. The slope range is 0 to 2 percent.

The available water capacity is low; the supply is rarely adequate for optimum growth of crops. Fertility is low but slightly higher in the Mancelona and Montcalm soils than in the others. The organic-matter content is low. Runoff is slow, and permeability is moderate to rapid. Soil blowing is a serious hazard if the soils are farmed intensively, but there is generally no hazard of water erosion.

Maintaining fertility, supplying organic matter, conserving moisture, and controlling soil blowing are the major management needs. Additions of organic matter are needed to help conserve moisture and maintain good tilth. Fertilizer is needed, but large applications are not beneficial in dry years when crops fail to mature because of lack of moisture. Windbreaks, stripcropping, and minimum tillage help to control blowing in cultivated areas. Other means of protecting the soils from wind damage include cover crops, buffer strips of small grain, plant residues left on the surface, and rough tillage.

Corn, small grain, and hay are the common crops. Crops that resist drought and mature early should be selected, unless irrigation is provided. Deep-rooted forge plants are better suited than shallow-rooted crops.

CAPABILITY UNIT IIIs–4 (4a, 4/2a)

This unit consists of moderately well drained to well drained soils of the Boyer, Mancelona, Menominee, Montcalm, Oshtemo, and Spinks series. These soils have a moderately fine textured to coarse-textured subsoil. The Menominee soil is underlain with moderately fine textured material, and the rest of the soils with coarse-textured material. The slope range is 2 to 6 percent.

The available water capacity of the Menominee soil is moderate, and that of the other soils is low. Normally, the soils are filled almost to capacity with moisture at the beginning of the growing season, then they become drier as the season progresses. The moisture supply is not adequate to carry crops through periods of dry weather. Fertility is generally low but is slightly higher in Mancelona, Menominee, and Oshtemo soils than in the others. The organic-matter content of all the soils is low. Runoff is slow. Permeability generally is moderate to rapid but is moderately slow in the lower part of the Menominee soil. These soils are easy to work throughout a wide range in moisture content, and they are not likely to clod or

crust. Excessive tillage increases the hazard of erosion. The Spinks soil is more droughty and more susceptible to blowing than the rest of the soils.

Improving fertility, supplying organic matter regularly, conserving moisture, and controlling erosion are the major management needs. Plowing under crop residues, green-manure crops, and barnyard manure increases fertility, supplies organic matter, and helps to conserve moisture. Fertilizer is needed, but large applications are not beneficial in dry years when crops fail to mature because of lack of moisture. Windbreaks, stripcropping, and minimum tillage help to control erosion.

Corn, small grain, and hay are the common crops. Crops that resist drought and mature early are to be preferred.

CAPABILITY UNIT IVe–1 (1.5a, 2.5a)

This unit consists of moderately well drained to well drained soils of the Miami and Nester series. These soils have a modrately fine textured subsoil and medium-textured to moderately fine textured underlying material. The slope range is 12 to 18 percent.

The available water capacity is high, and fertility is medium to high. The organic-matter content is low. Permeability is moderate to moderately slow. Where crops are grown, runoff is rapid and, consequently, the erosion hazard is serious. The rapid runoff also results in a shortage of moisture in summer.

Controlling erosion, supplying organic matter, and maintaining good tilth are the major management needs. Minimum tillage, contour stripcropping, and a preponderance of forage crops in the cropping system help to reduce runoff and control erosion. Where the slopes are too short or too complex for stripcropping, erosion can be controlled by planting only close-growing crops. Plowing under large amounts of organic matter increases the water-absorbing capacity of the soils and thus saves water that would otherwise run off. Grassed waterways are needed to dispose of runoff safely.

These soils are suited to forage crops and an occasional crop of small grain. Only infrequently should a row crop be grown. Frost-free sites are suitable for fruit trees. A cover of permanent vegetation should be established between the trees.

CAPABILITY UNIT IVe–3 (1.5a)

This unit consists of Nester clay loam, 6 to 12 percent slopes, severly eroded. This soil is moderately well drained to well drained. Both the subsoil and the underlying material are moderately fine textured.

The available water capacity is high, and fertility is medium. The organic-matter content is low. Runoff is very rapid in areas intensively farmed. Permeability is moderately slow. The surface layer has poor structure and tilth; it is sticky when wet and becomes hard and crusted upon drying. When the soil is hard, runoff increases. The crust hinders the germination of seeds and the emergence of seedlings. The hazard of further erosion is serious.

Controlling erosion, supplying organic matter regularly and improving tilth are the major management needs. Means of controlling erosion include contouring, terracing, stripcropping, minimum tillage, cover crops, and the inclusion of grasses and legumes in the cropping system. Where mechanical practices for control of erosion are not feasible, the crops should be mainly small grain and forage plants. Crop residues should be kept on or near the surface. Partially incorporating crop residues or manure reduces the tendency of the soil to clod and crust. Tilling when the moisture content is favorable helps to prevent deterioration of tilth.

This soil is better suited to small grain and forage crops than to row crops. A row crop should be grown only occasionally.

CAPABILITY UNIT IVe–9 (4a)

This unit consists of moderately well drained to well drained soils of the Montcalm, Oshtemo, and Spinks series. These soils have a coarse-textured to moderately fine textured subsoil and coarse-textured underlying material. Most of the acreage is slightly eroded. The slope range is 12 to 18 percent.

The available water capacity is low, fertility is low, and the organic-matter content is low. Where crops are grown, runoff is rapid and the hazard of erosion is serious. Permeability is moderate to rapid. Heavy runoff and low available water capacity result in a shortage of moisture during the dry summer months. Soil blowing is a hazard if large areas are cultivated.

Controlling erosion and conserving moisture are the major management needs. Minimum tillage, stubble mulching, and stripcropping help to slow runoff and control erosion. Where the slopes are short and uneven and stripcropping is not practical, a permanent cover of grass is needed for control of erosion. Gullies form in pastures that are overgrazed. Pasture stands improve if fertilizer and organic matter are added. Large applications of fertilizer are not beneficial in dry years when crops fail to mature because of lack of moisture.

These soils are better suited to small grain and forage crops than to row crops. Some fruit trees are grown.

CAPABILITY UNIT IVw–2 (5b)

This unit consists of two somewhat poorly drained soils of the Au Gres series. One of these soils is coarse textured throughout, and the other has moderately fine textured underlying material at a depth of 42 to 66 inches. The slope range is 0 to 6 percent.

The available water capacity is low, fertility is low, and the organic-matter content is low. Runoff is slow, and water ponds in depressions. Permeability is rapid in the coarse-textured material and moderately slow in the moderately fine textured material. The water table is high in spring. If it is lowered by artificial drainage, the soils tend to become droughty. Soil blowing is a hazard if large areas are cultivated.

Drainage, conservation of moisture after drainage, and improvement of fertility are the major management needs. Installing drainage systems is difficult. Ditchbanks and trenches cave in readily when the soil is wet, and soil material fills the drains. Tile should be installed when the soils are dry. Backfilling with porous material, such as straw, topsoil, or grass clippings, helps to keep the drains clear. Stripcropping, windbreaks, cover crops, mulches, and minimum tillage help to conserve moisture and to control soil blowing. Fertilizer is needed, but large applications are not beneficial in dry years when crops fail to mature because of lack of moisture.

These soils are not well suited to general crops, but blueberries, strawberries, melons, and other truck crops can

be grown in areas where drainage is feasible and water is available for irrigation.

CAPABILITY UNIT IVw-3 (5b, 5b-h)

This unit consists of Au Gres-Saugatuck sands, 0 to 6 percent slopes, a complex of two somewhat poorly drained soils. Both soils are coarse textured throughout. The Saugatuck soil has a cemented layer in the subsoil.

The available water capacity is low, fertility is low, and the organic-matter content is low. Runoff is very slow to ponded. The Au Gres soil is rapidly permeable, but the Saugatuck soil, because of the cemented layer, is slowly permeable. The water table is near the surface in spring and during wet weather in other seasons. If the water table is lowered by artificial drainage, the soils are droughty during dry weather. Large cultivated fields are susceptible to soil blowing.

Drainage, conservation of moisture during dry weather, and improvement of fertility are the major management needs. Drainage is difficult because trenches and ditches cave in. The cemented layer in the Saugatuck soil necessitates onsite investigation before drainage is attempted. Special blinding and backfilling help to keep sand out of the drains. Drainage systems should include water level controls so that the water table can be kept at a level favorable for the growth of crops. Irrigation is needed during dry periods. Cover crops, crop residues, and green-manure crops supply organic matter and thus improve the available water capacity. Field windbreaks, stripcropping, rough tillage, residues left on the surface, and cover crops or strips of small grain help to control soil blowing.

General crops are seldom grown on these soils, but blueberries, strawberries, melons, and some truck crops can be grown where the degree of soil acidity is favorable, air drainage is good, lowering the water table is feasible, and water is available for irrigation.

CAPABILITY UNIT IVw-5 (M/4c, Mc)

This unit consists of poorly drained organic soils of the Adrian and Houghton series. In the Adrian soil the organic deposit is 12 to 42 inches thick and is underlain with coarse-textured mineral material. In the Houghton soil the organic deposit is 42 or more inches in thickness. The slope range is 0 to 2 percent and the topography is level to depressional.

The available water capacity of the Adrian soil is moderate, and that of the Houghton soil is very low. Fertility is low. Runoff is very slow to ponded, and permeability is rapid. The water table is high. Farm machinery bogs down readily when the soils are saturated, and planting and harvesting are hampered. If the water table is lowered too much, the organic material settles and in some places dries out so much that hazards of soil blowing and fire develop. Wind action thins the layer of organic material, blows out newly seeded crops, and fills drainage ditches with drifting soil material. Frost damage to crops is also a hazard.

Drainage, control of soil blowing, and improvement of fertility are the major management needs. Dams, dikes, pumps, and irrigation wells are among the means that can be used to keep the water table at a favorable level. Tile, open ditches, and surface drains are effective also. The water table should be low enough that crops can be grown, but not so low as to result in droughtiness or to intensify the hazard of blowing. The risk of settling can be reduced by keeping the water table near the surface in areas where no crop is being grown. Compaction of the surface layer, sprinkler irrigation, stripcropping, and the use of buffer strips and windbreaks help to control soil blowing. The danger of frost damage can be reduced by selecting frost-hardy crops and planting only where air drainage is good. The fertilizer elements generally needed are phosphorus, potassium, manganese, boron, copper, molybdenum, and zinc. These should be applied according to the results of soil tests, in quantities that will meet the needs of whatever crops are being grown. Grazing when the soils are wet should be restricted.

Corn and vegetable crops are grown in drained areas of these soils. Areas that cannot be drained are used for grazing.

CAPABILITY UNIT IVw-6 (M/mc)

This unit consists of very poorly drained organic soils of the Edwards and Warners series. In the Edwards soil the organic material is underlain with marl at a depth of 12 to 42 inches, and in the Warners soil, at a depth of less than 12 inches. The slope range is 0 to 2 percent.

The available water capacity is high, and fertility is low. Runoff is very slow to ponded. Permeability varies because of differences in the underlying marl. The water table is at the surface part of the year unless lowered by artificial drainage. Soil blowing in cultivated areas is a serious hazard. Frost damage to crops is a hazard, also.

Drainage, control of soil blowing, and improvement of fertility are the major management needs. Some areas can be drained by means of tile, open ditches, and surface drains. The Warners soil and some areas of the Edwards soil are difficult to drain because the marl is so near the surface. Compaction of the surface layer, sprinkler irrigation, stripcropping, and the use of windbreaks help to control soil blowing. Fertilizer should be applied according to the results of soil tests, in quantities that will meet the needs of whatever crops are being grown. Grazing when the soils are wet should be restricted.

Drained areas of the Edwards soil are used for corn and vegetable crops. Most of the Warners soil and those areas of the Edwards soil that cannot be drained are used for grazing.

CAPABILITY UNIT IVs-4 (5a, 5b)

This unit consists of soils of the Au Gres, Chelsea, Croswell, and Kalkaska series. The Au Gres soil is somewhat poorly drained, the Croswell soils are moderately well drained, and the Chelsea and Kalkaska soils are well drained. The Chelsea soils have a thin, moderately coarse textured subsoil and coarse textured underlying material. All the other soils are coarse textured throughout. The Kalkaska soil has a slope range of 0 to 12 percent; the rest have a slope range of 0 to 6 percent.

The available water capacity is low, and fertility is low. The organic matter content is very low to low. Very little water runs off. Permeability is rapid.

Conserving moisture, controlling soil blowing, and improving fertility are the major management needs. Minimum tillage helps to limit the loss of moisture through evaporation. Windbreaks, cover crops, stripcropping, mulches, and minimum tillage help to control soil blowing. Fertilizer is needed, but large applications are not beneficial in dry years when, because moisture is lacking, crops fail to mature.

Only a few areas of these soils are farmed. Crops quickly

show the effects of droughtiness. Small fruits and truck crops, grown under irrigation, are better suited than other cultivated crops. Shallow-rooted crops do not mature in dry years. Early maturing crops can be grown, and forage crops do well in the early part of the growing season. Small areas of the Kalkaska soil are steep enough to need a cover of permanent vegetation.

CAPABILITY UNIT VIe–1 (1.5a, 2.5a)

This unit consists of moderately well drained to well drained soils of the Miami, Morley, and Nester series. These soils have a moderately fine textured subsoil and medium-textured to moderately fine textured underlying material. One soil in the unit is moderately eroded, and two are severely eroded. The slope range is 12 to 45 percent.

The available water capacity is high, and fertility is medium to high. The organic-matter content is low. Runoff is rapid to very rapid. Permeability is moderately slow to moderate. The two severely eroded soils are lower in fertility, have poorer tilth, have a lower content of organic matter, and lose more water through runoff than the rest of the soils in the unit.

Controlling erosion and improving tilth are the major management needs. Close-growing vegetation helps to control erosion. Grassed waterways can be used in some areas to check runoff and thus reduce the erosion hazard. Minimum tillage, utilization of crop residues, and application of lime and fertilizer help to maintain fertility and improve tilth. Careful management of grazing also helps to reduce the erosion hazard and improve tilth.

Because of the slope and the risk of further erosion, these soils are better suited to pasture and forage crops than to row crops or small grain.

CAPABILITY UNIT VIs–1 (4a, 5a)

This unit consists of moderately well drained to well drained soils of the Chelsea, Montcalm, and Spinks series. These soils have a coarse textured to moderately coarse textured subsoil and coarse textured underlying material. The slope range is 6 to 25 percent.

The available water capacity is low, and fertility is low. The organic-matter content is very low to low. Runoff is medium, and permeability is moderately rapid to rapid. These soils dry out quickly. They are easy to till but are readily eroded.

Conserving moisture and controlling erosion are the major management needs. A cover of permanent vegetation helps to do both. Minimum tillage, addition of organic matter, and application of lime and fertilizer also help to conserve moisture. Careful management of grazing is necessary to prevent intensifying the erosion hazard.

Recreation, wildlife habitat, and woodland are better uses for these soils than the production of crops. Pasture and forage crops are better suited than row crops and small grain, but even they are adversely affected by the moisture shortage.

CAPABILITY UNIT VIIe–1 (1.5a)

This unit consists of moderately well drained to well drained soils of the Morley and Nester series. These soils have a moderately fine textured subsoil and moderately fine textured underlying material. Three of the four soils in the unit are severely eroded. The slope range is 18 to 45 percent.

The available water capacity is high, and fertility is generally medium. The organic-matter content is low. Runoff is very rapid, and the erosion hazard is severe. Permeability is moderately slow.

Controlling erosion is the major management need. Maintaining a cover of permanent vegetation is most important. Planting trees and shrubs is beneficial. Overgrazing results in increased runoff and an intensified erosion hazard.

These soils are too steep and too eroded to be used for cultivated crops. They are better suited to grass or to recreational uses, wildlife habitat, or woodland.

CAPABILITY UNIT VIIe–2 (4a)

This unit consists of Spinks and Montcalm loamy sands, 25 to 45 percent slopes, an undifferentiated group of moderately well drained to well drained soils that have a moderately coarse textured to coarse textured subsoil and coarse textured underlying material.

The available water capacity is low, fertility is low, and the organic-matter content is low. Runoff is rapid, and permeability is moderately rapid to rapid.

Controlling erosion is the major management need. Maintaining a cover of permanent vegetation is most important. Planting trees and shrubs is beneficial. Careful management of grazing is needed because overgrazing intensifies the erosion hazard.

These soils are too steep and too droughty to be used for cultivated crops. They are better suited to grass or to recreational uses, wildlife habitat, or woodland. Even pastures dry up in summer. Because of the slope, the use of machinery is restricted.

CAPABILITY UNIT VIIs–1 (5.3a)

This unit consists of well-drained soils of the Deer Park and Rubicon series and two phases of one land type, Blown-out land. All of these mapping units are coarse textured throughout. The slope range is 0 to 50 percent.

The available water capacity is very low, and fertility is very low. The organic-matter content is very low, and the organic matter decomposes rapidly under cultivation. Runoff is very slow to slow, and permeability is rapid.

Controlling erosion is the major management need. A permanent cover of grass, shrubs, or trees is needed.

These soils are not suitable for cultivated crops, and even pasture plants dry up in summer and provide little forage. The slope restricts the use of farm machinery. Recreation, wildlife habitat, and woodland are suitable uses. Christmas trees can be grown on some areas of the Rubicon soils (fig. 10). Blown-out land can be stabilized by planting beachgrass and, after that is established, setting out shrubs and trees.

CAPABILITY UNIT VIIIw–2 (Sc)

This unit consists of Marsh, a land type in which the water table is at or above the surface most of the year. The soil material is predominantly peat. Most areas are along the Grand River, where the river flows into Lake Michigan.

Marsh is not suitable for use as pasture, cropland, or woodland. It is best suited to recreational uses and wildlife habitat.

CAPABILITY UNIT VIIIs–1 (Sa)

This unit consists of five miscellaneous land types that are generally unsuitable for farming. Some areas have

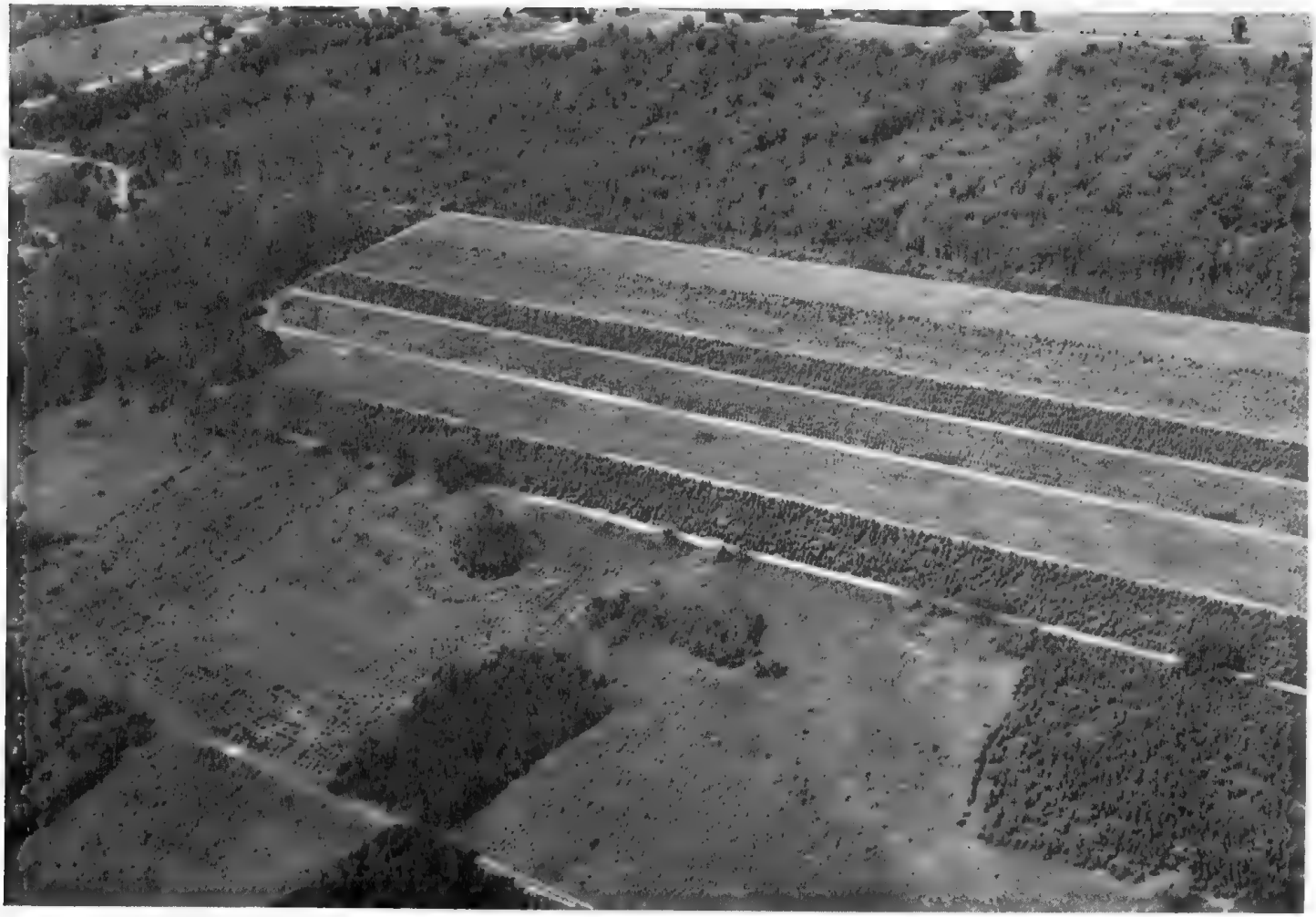

Figure 10.—**Christmas tree plantation on a Rubicon sand, which is in capability unit VIIs–1 (5.3a).**

possibilities for recreational uses, and other areas have already been used for commercial and residential building. Areas that are actively eroding need to be stabilized by planting beachgrass or brush and, after these have become established, setting out trees and shrubs.

Predicted Yields [3]

Table 2 shows the predicted yields per acre of the principal crops grown in Ottawa County, under prevailing management and under improved management. These predictions are indicative of the relative productivity of the soils of the county.

The figures in columns A represent recorded yields under prevailing management. At this level of management, some legume-grass crops are included in the cropping system but generally little consideration is given to the suitability of the cropping system for the soil; the available barnyard manure is returned to the soil; lime is applied, but in many places in insufficient amounts and not according to recommendations based on soil tests; some fertilizer is applied; poorly drained soils are cultivated without being drained artificially, so partial crop failures caused by excess water are common; and erosion control and other management practices are not used to the fullest advantage.

The figures in columns B represent yields obtained under improved management, which includes most of the following: suitable cropping systems, in which the proper proportion of row crops to legume-grass crops is maintained; such measures as are needed to control water erosion and soil blowing (contour tillage, stripcropping, minimum tillage, and return of crop residues, for example); applications of lime and fertilizer in accordance with the results of soil tests and the requirements of the crop; adequate artificial drainage, where needed; use of improved varieties of crops and of high-quality seed; control of weeds, diseases, and insects; suitable and well-timed tillage and harvesting; and utilization of cover crops, crop residues, and manure to improve soil structure, supply organic matter, and help control erosion.

These yields are averages for a period of several years under the specified level of management. The predictions for improved management are not presumed to be the

[3] WILLIAM ALLRED and WARREN STUDLEY, Soil Conservation Service, helped prepare this section.

TABLE 2.—*Predicted yields under two levels of management*

[Columns A show yields to be expected under prevailing management in the county; columns B show yields that can be obtained under improved management. Dashes indicate that the crop is not suited to the soil or is not ordinarily grown on it]

Soil	Corn (grain)		Corn (silage)		Oats		Wheat		Alfalfa		Mixed hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Adrian muck	60	90	9	13								
Adrian-Houghton mucks	60	100	9	14								
Algansee loamy sand												
Allendale sandy loam, 0 to 4 percent slopes	60	85	9	12	40	75	32	45	2.4	4.5	1.2	2.0
Au Gres loamy sand, 0 to 6 percent slopes	30	60	4	9	20	55	16	35	1.3	2.1	1.1	1.8
Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes	30	60	5	9	20	55	16	35	1.3	2.1	1.1	1.8
Au Gres-Saugatuck sands, 0 to 6 percent slopes	30	60	5	9	20	55	16	35	1.3	2.1	1.1	1.8
Belding sandy loam, 0 to 2 percent slopes	60	85	9	12	40	75	32	45	2.4	4.0	1.5	2.5
Belding sandy loam, 2 to 6 percent slopes	60	85	9	12	40	75	32	45	2.4	4.0	1.5	2.5
Blount loam, 0 to 2 percent slopes	65	110	8	16	48	75	38	50	2.5	5.0	1.8	2.6
Blount loam, 2 to 6 percent slopes	65	110	8	16	48	75	38	50	2.5	5.0	1.8	2.6
Blown-out land, 0 to 6 percent slopes												
Blown-out land, 6 to 50 percent slopes												
Bowers loam, 0 to 2 percent slopes	60	110	8	16	48	75	35	50	2.5	5.0	1.8	2.6
Bowers loam, 2 to 6 percent slopes	65	110	8	16	48	75	38	50	2.5	5.0	1.8	2.6
Boyer loamy sand, 0 to 2 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Boyer loamy sand, 2 to 6 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Boyer loamy sand, 6 to 12 percent slopes	30	60	4	9	25	45	16	26	1.5	2.6	1.2	2.0
Breckenridge sandy loam	50	80	7	11	40	75	32	45	2.4	4.0	1.5	3.0
Brevort sandy loam	50	80	7	11	35	60	25	38	1.5	3.2	1.5	3.0
Bruce loam	65	100	9	14	45	73	35	50	2.5	5.0	1.8	2.6
Carlisle muck	60	100	9	14								
Ceresco loam	50	90	7	13	40	70	20	40	1.9	3.5	1.8	2.9
Chelsea loamy sand, 0 to 6 percent slopes									1.5	2.0	1.5	2.0
Chelsea loamy sand, 6 to 12 percent slopes									1.2	2.0	1.2	2.0
Chelsea complex, 0 to 6 percent slopes									1.7	2.2	1.7	2.2
Cohoctah loam	50	90	7	13	40	70	20	40	1.9	3.5	1.8	2.9
Conover loam, 2 to 6 percent slopes	80	110	11	16	50	80	38	50	2.5	5.0	1.8	2.0
Croswell sand, 0 to 6 percent slopes	20	50	3	7	18	34	13	22	1.2	2.0	1.0	1.5
Croswell and Au Gres sands, 0 to 6 percent slopes	30	60	5	9	20	55	16	35	1.3	2.1	1.1	1.8
Deer Park sand, 0 to 6 percent slopes												
Deer Park sand, 6 to 18 percent slopes												
Deer Park sand, 18 to 45 percent slopes												
Edwards muck	60	90	9	13								
Fox sandy loam, 0 to 6 percent slopes	60	85	9	13	40	75	32	45	2.4	4.0	1.5	2.2
Gilford sandy loam	55	80	8	11	35	60	25	38	2.0	4.0	1.5	2.5
Gladwin sandy loam, 0 to 2 percent slopes	55	75	8	10	35	55	25	35	2.0	4.0	1.5	2.5
Gladwin sandy loam, 2 to 6 percent slopes	55	75	8	10	35	55	25	35	2.0	4.0	1.5	2.5
Glendora sandy loam												
Granby loamy sand	50	70	7	10	22	45	12	25	1.2	2.2	1.0	1.8
Granby fine sandy loam	50	75	7	10	22	45	12	30	1.2	2.2	1.0	1.8
Gravel pits												
Hettinger loam	65	110	9	16	48	75	35	50	2.5	5.0	1.8	2.6
Hillsdale sandy loam, 2 to 6 percent slopes	60	85	9	13	40	75	32	45	2.4	4.0	1.5	2.2
Hillsdale sandy loam, 6 to 12 percent slopes	50	80	8	12	35	70	30	40	2.4	4.0	1.5	2.2
Iosco loamy sand, 0 to 4 percent slopes	60	85	9	12	40	75	32	45	2.5	4.5	1.2	2.0
Iosco and Allendale loamy sands, 0 to 4 percent slopes	60	80	9	11	40	75	32	45	2.5	4.5	1.2	2.0
Iosco-Belding complex, 2 to 6 percent slopes	60	80	9	11	40	75	32	45	2.5	4.5	1.2	2.0
Kalkaska sand, 0 to 12 percent slopes												
Kawkawlin loam, 0 to 2 percent slopes	65	110	9	16	48	75	35	50	2.5	5.0	1.8	2.6
Kawkawlin loam, 2 to 6 percent slopes	70	110	10	16	48	75	35	50	2.5	5.0	1.8	2.6
Kibbie loam, 0 to 2 percent slopes	65	100	9	14	45	75	35	50	2.5	5.0	1.8	2.6
Kibbie loam, 2 to 6 percent slopes	65	100	9	14	45	75	35	50	2.5	5.0	1.8	2.6
Lacota silt loam	60	85	9	12	40	75	27	45	2.5	4.0	1.7	2.5
Lake beaches												
Linwood muck	60	100	9	14								
Made land												
Mancelona loamy sand, 0 to 2 percent slopes	50	75	5	10	30	50	25	35	2.5	4.0	1.2	2.0
Mancelona loamy sand, 2 to 6 percent slopes	50	75	5	10	30	50	25	35	2.5	4.0	1.2	2.0
Mancelona loamy sand, 6 to 12 percent slopes	50	65	4	9	25	45	20	30	2.5	4.0	1.2	2.0
Marsh												
Matherton loam, 0 to 2 percent slopes	65	100	9	14	45	75	35	50	2.5	5.0	1.8	2.6
Menominee loamy sand, 2 to 6 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Menominee loamy sand, 6 to 12 percent slopes	30	60	4	9	25	45	16	26	1.5	2.6	1.2	2.0

TABLE 2.—*Predicted yields under two levels of management*—Continued

Soil	Corn (grain)		Corn (silage)		Oats		Wheat		Alfalfa		Mixed hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Metamora sandy loam, 0 to 2 percent slopes	60	85	9	12	40	75	32	45	2.4	4.5	1.5	2.5
Metamora sandy loam, 2 to 6 percent slopes	60	85	11	20	40	75	32	45	2.4	5.0	1.5	2.5
Miami loam, 2 to 6 percent slopes	70	100	10	14	50	80	35	50	2.5	5.0	1.5	3.0
Miami loam, 6 to 12 percent slopes	65	90	9	13	50	80	35	50	2.5	5.0	1.5	3.0
Miami loam, 12 to 18 percent slopes									2.5	4.0	1.0	2.5
Miami loam, 18 to 45 percent slopes												
Montcalm loamy sand, 0 to 2 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Montcalm loamy sand, 2 to 6 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Montcalm loamy sand, 6 to 12 percent slopes	30	60	4	9	25	45	16	26	1.5	2.6	1.2	2.0
Morley loam, 2 to 6 percent slopes	50	90	8	14	48	70	32	45	2.3	4.0	1.8	2.6
Morley loam, 6 to 12 percent slopes, eroded	50	90	8	14	42	65	32	45	2.3	4.0	1.8	2.6
Morley loam, 18 to 25 percent slopes, eroded									2.0	3.7	1.5	2.3
Morley clay loam, 12 to 18 percent slopes, severely eroded									2.0	3.7	1.5	2.3
Morley clay loam, 25 to 45 percent slopes, severely eroded												
Nester loam, 2 to 6 percent slopes	55	100	8	14	48	75	32	50	2.3	5.0	1.8	3.0
Nester loam, 6 to 12 percent slopes	50	90	7	13	42	65	30	45	2.3	4.0	1.8	2.6
Nester loam, 12 to 18 percent slopes					25	55	15	30	2.0	3.7	1.5	2.3
Nester loam, 18 to 25 percent slopes												
Nester loam, 25 to 45 percent slopes												
Nester clay loam, 6 to 12 percent slopes, severely eroded	45	75	6	10	42	65	28	38	2.3	4.0	1.8	2.6
Nester clay loam, 12 to 18 percent slopes, severely eroded									1.5	3.0	1.5	2.5
Nester clay loam, 18 to 25 percent slopes, severely eroded												
Nester clay loam, 25 to 45 percent slopes, severely eroded												
Newaygo sandy loam, 0 to 6 percent slopes	60	85	9	13	40	75	32	45	2.4	4.0	1.5	2.2
Oshtemo sandy loam, 0 to 2 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Oshtemo sandy loam, 2 to 6 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Oshtemo sandy loam, 6 to 12 percent slopes	30	60	4	9	25	45	16	26	1.5	2.6	1.2	2.0
Oshtemo sandy loam, 12 to 18 percent slopes					20	40	12	24	1.5	2.5	1.2	2.0
Owosso sandy loam, 2 to 6 percent slopes	60	85	9	12	40	75	32	40	2.4	4.0	1.5	2.2
Pinconning loamy sand	60	80	9	11	40	75	32	45	2.5	4.5	1.2	2.0
Pinconning and Breckenridge sandy loams	50	80	7	11	35	60	25	38	1.5	3.2	1.5	3.0
Richter sandy loam, 0 to 2 percent slopes	60	80	9	12	40	75	27	45	2.1	3.3	1.7	2.5
Richter sandy loam, 2 to 6 percent slopes	60	80	8	12	40	75	27	45	2.1	3.3	1.7	2.5
Rubicon sand, 0 to 6 percent slopes												
Rubicon sand, 6 to 18 percent slopes												
Rubicon sand, 18 to 45 percent slopes												
Sand pits												
Selkirk loam, 0 to 2 percent slopes	55	90	8	13	48	75	30	45	2.5	3.5	1.8	2.6
Selkirk loam, 2 to 6 percent slopes	55	90	8	13	48	75	30	45	2.5	3.5	1.8	2.6
Shoals loam	50	90	7	13	40	70	20	40	1.9	3.5	1.8	2.9
Sims loam	65	110	9	16	48	75	35	50	2.5	5.0	1.8	2.6
Sloan loam	50	90	7	13	40	70	20	40	1.9	3.5	1.8	2.9
Spinks loamy sand, 0 to 2 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Spinks loamy sand, 2 to 6 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Spinks loamy sand, 6 to 12 percent slopes	30	60	4	9	25	45	16	26	1.5	2.6	1.2	2.0
Spinks and Montcalm loamy sands, 12 to 18 percent slopes					20	40	12	24	1.5	2.5	1.2	2.0
Spinks and Montcalm loamy sands, 18 to 25 percent slopes												
Spinks and Montcalm loamy sands, 25 to 45 percent slopes												
Toledo silty clay loam	50	90	7	13	45	65	27	40	2.0	3.5	1.5	2.5
Tonkey sandy loam	55	80	8	12	40	75	27	45	2.1	3.3	1.7	2.5
Tuscola fine sandy loam, 2 to 6 percent slopes	70	90	10	13	50	80	35	50	2.5	5.0	1.5	3.0
Ubly sandy loam, 0 to 2 percent slopes	60	85	9	13	40	75	32	40	2.4	4.0	1.5	2.2
Ubly sandy loam, 2 to 6 percent slopes	60	85	9	12	40	75	32	40	2.4	4.0	1.5	2.2
Ubly sandy loam, 6 to 12 percent slopes	55	80	8	11	35	70	28	38	2.4	4.0	1.5	2.2
Wallkill silt loam	70	90	10	13								
Warners muck												
Wasepi sandy loam, 0 to 2 percent slopes	55	75	8	10	35	55	25	35	2.0	4.0	1.5	2.5
Washtenaw loam	50	90	7	13	40	70	20	40	1.9	3.5	1.8	2.9
Wind eroded land, sloping												

Figure 11.—**Pulpwood harvested in thinning a plantation of red pine.**

maximum obtainable; the potential yields under a favorable combination of conditions are somewhat higher. Irrigation is not considered in predicting yields under improved management, because it is little used except for truck crops and fruit.

Woodland [4]

When settlement of the area began, Ottawa County was almost entirely covered with forest. Hardwoods, including oak, beech, and maple, grew on the finer textured soils, and white pine on the sandy soils. The first sawmill in the county was built in 1836, at the mouth of the Grand River, the site of the town of Grand Haven. By 1870 there were 32 operating sawmills in the county, but by 1890 some of the large mills had ceased operations. Several small sawmills still exist, but their output of wood products is less than 7 percent of the amount produced in 1870. Pulpwood (fig. 11) and Christmas trees are the main forest products at present.

By 1938 about 17 percent of the acreage of the county had been so badly damaged by soil blowing as to be severely limited for farming. Much of this acreage has been stabilized and is now producing wood crops, principally Christmas trees. Some areas still need to be reforested. The practices needed in management of existing woodlands include protection from fire and grazing, underplanting with suitable species, removal of culls, and timely harvesting. Plantations may need to be thinned and pruned.

Woodland suitability groups

To assist owners and managers in planning woodland management, the soils of Ottawa County are grouped into 17 woodland suitability groups. Each group consists of soils that are similar in potential productivity, in requirements for conservation practices, and in response to woodland management. Suitability for Christmas trees and other special wood crops was not taken into account. Gravel pits and Made land are not placed in woodland suitability groups, because they ordinarily do not support trees of any kind.

Each woodland suitability group is identified by a letter of the alphabet. The grouping is on a statewide basis, and not all the groups in the system are represented in Ottawa

[4] JACQUES PINKARD, woodland conservationist, Soil Conservation Service, helped prepare this section.

County; consequently, the groups described here are not lettered consecutively.

The description of each group gives information about the pertinent properties of the soils, the major limitations, potential productivity for the major species, and selection of species to be favored in management. The major limitations, which are rated slight, moderate, or severe for each group, are seedling mortality, plant competition, equipment limitation, erosion hazard, and windthrow hazard.

Potential productivity.—The ratings of potential productivity used in the descriptions of the woodland suitability groups are based on the average annual rate of growth in fully stocked stands that are well managed but not fertilized or artificially drained. Fully stocked stands have the amount of growing stock needed for maximum growth; the number of trees per acre depends on the species and on the age and size of the trees. Fully stocked stands sustain production if well managed. Primarily, they need to be protected from fire and from grazing. Timely and orderly thinning and harvesting improve protected stands. Many stands in Ottawa County are overstocked. Many contain undesirable kinds of trees, but most include enough trees of useful species to make management worth while.

The ratings can be translated into terms of board feet per acre or cords per acre, as follows: *Very high*, more than 325 board feet or more than 1.2 cords; *high*, 275 to 325 board feet or 0.8 to 1.2 cords; *medium*, 200 to 275 board feet or 0.5 to 0.8 cord; *low*, 185 to 200 board feet or 0.2 to 0.5 cord; and *very low*, less than 125 board feet or less than 0.2 cord.

Potential productivity reflects the influence of soil properties, climate (particularly drought), insects and diseases, genetic factors, and other circumstances that affect the growth of trees. The ratings given in any one description represent the range for the group, not that for any particular soil.

Species priority.—The suggestions for species to be favored in managing woodland stands apply also to planting. The selections are based on potential productivity and relative commercial value. Disease and insect hazards are not taken into account. The species are listed in order of suitability.

Seedling mortality.—This refers to the loss of naturally occurring or planted seedlings as a result of unfavorable soil properties or topography, not as a result of plant competition. The rating is *slight* if the loss is expected to be less than 25 percent; *moderate* if the loss is expected to be between 25 and 50 percent; and *severe* if the loss is expected to be more than 50 percent.

Plant competition.—This refers to the growth of undesirable vegetation on a site that has been disturbed by logging, fire, or other causes. The competing vegetation hinders or prevents the reestablishment of trees of the desired species. A rating of *slight* means that competition from other vegetation is no special problem, a rating of *moderate*, that competition delays natural or artificial regeneration but does not prevent the establishment of a normal, fully stocked stand; and a rating of *severe*, that competition prevents natural restocking and necessitates intensive management if seedlings are planted.

Equipment limitation.—This refers to the effects of unfavorable soil properties or topography on the use of equipment commonly used for planting and harvesting trees. A rating of *slight* means that there is no significant limitation; a rating of *moderate*, that not all types of equipment can be used and that, for a period of no more than 3 months out of a year, no such equipment can be used; and a rating of *severe*, that the kind of planting and harvesting equipment that can be used at any time without damaging trees is limited and that, for a period of more than 3 months out of a year, no such equipment can be used.

Erosion hazard.—This refers to the potential for erosion if trees, undergrowth, shrubs, other growing plants, and plant litter are removed. Good woodland management, including fire prevention and careful construction and maintenance of roads, skid trails, and loading areas, prevents the development of an erosion hazard. A rating of *slight* indicates that damage from erosion is not likely after clear cutting by ordinary methods; a rating of *moderate*, that some care must be taken and some protective cover provided after clear cutting; and a rating of *severe*, that gullies and blowouts are likely to form after clear cutting unless the area has a dense ground cover, and also that roads and trails are likely to be washed out unless suitably located and stabilized.

Windthrow hazard.—This refers to the danger of trees being blown over by the wind. A rating of *slight* means that trees are not expected to be blown down in commonly occurring winds; a rating of *moderate* means that trees generally withstand winds of medium intensity, that scattered trees on unprotected sites are likely to be blown down, and that protective measures are needed in harvesting and release cutting; a rating of *severe* means that, because of a high water table, a pan, or some other kind of restrictive layer, trees do not have roots deep enough for adequate anchorage.

WOODLAND SUITABILITY GROUP A

This group consists of well drained to moderately well drained soils of the Newaygo, Owosso, and Ubly series. These soils have a moderate available water capacity and medium fertility. The slope range is 0 to 12 percent.

The equipment limitation is slight, and so are the hazards of erosion, windthrow, and insect and disease damage. Plant competition is moderate, and seedling mortality is slight to moderate.

Red oak, sugar maple, white oak, basswood, white ash, black cherry, and black walnut are the native species to be favored. Red oak, black walnut, and sugar maple have the highest economic value. White pine, red pine, and white spruce are the species most commonly planted. Potential productivity is medium to high for all these species.

WOODLAND SUITABILITY GROUP B

This group consists of moderately well drained to well drained soils of the Morley and Nester series. These soils are high in available water capacity and in fertility. The slope range is 2 to 45 percent.

The hazards of insect and disease damage and of windthrow are slight. Plant competition is moderate to severe; without special site preparation, grass and other plants invade openings in natural stands and prevent adequate restocking. Seedling mortality is slight to moderate, depending on whether competing vegetation is controlled. The erosion hazard is moderate to severe, depending on the slope. The equipment limitation also is moderate to severe.

Sugar maple, red oak, basswood, black cherry, and black

walnut are the native species to be favored. White spruce, Norway spruce, and white pine are the species most commonly planted. Potential productivity is very high for mixed hardwoods, high for oak, and low to medium for pine.

WOODLAND SUITABILITY GROUP C

This group consists of moderately well drained to well drained soils of the Mancelona, Menominee, and Montcalm series. These soils generally have a low available water capacity and are droughty in dry weather. They are low in fertility. The Menominee soils have loamy underlying material at a depth of 18 to 40 inches, and the Mancelona soils have gravelly and sandy underlying material. The slope range is 0 to 45 percent.

Seedling mortality, plant competition, and the hazards of windthrow and of insect and disease damage are all slight. The equipment limitation and the erosion hazard are slight to severe, depending on the slope. On the steeper slopes seedlings may have to be planted by hand and roads and skid trails should follow the contour. Machine planting should be on the contour wherever possible.

White pine, red oak, white oak, and sugar maple are the native species to be favored. White pine, red pine, and white spruce are the species commonly planted. Scotch pine is grown for Christmas trees. Potential productivity is high to very high for pine and medium to high for oak and for mixed hardwoods.

WOODLAND SUITABILITY GROUP D

This group consists of well-drained soils of the Miami series. These soils have a high available water capacity and medium fertility. The slope range is 2 to 45 percent.

The hazards of windthrow and of insect and disease damage are slight. Plant competition is moderate. Seedling mortality is slight. The equipment limitation and the erosion hazard are slight where the slope is less than 12 percent, moderate where the slope is between 12 and 18 percent, and severe where it is more than 18 percent. On the steeper slopes planting and harvesting equipment cannot be used efficiently and seedlings have to be planted by hand. Roads, skid trails, and loading areas should, so far as possible, be located on the less sloping soils. Natural litter in drainageways should not be disturbed. Areas from which the original cover has been removed needs to be protected by seeding grass, planting trees, or mulching.

Red oak, white oak, white ash, walnut, black cherry, basswood, and sugar maple are the native species to be favored. White spruce, white pine, Norway spruce, and Austrian pine are the species most commonly planted. Black walnut and yellow-poplar are suitable for interplanting in the native stands. Potential productivity is very high for hardwoods and low to medium for pine.

WOODLAND SUITABILITY GROUP E

This group consists of moderately well drained to well drained soils of the Chelsea, Croswell, and Spinks series. These soils have a low available water capacity and low fertility. The slope range is 0 to 12 percent.

Plant competition, seedling mortality, and the hazards of windthrow and of insect and disease damage are all slight. The equipment limitation and the erosion hazard are also slight, but some precautions are needed. The use of planting and harvesting equipment is somewhat restricted where the slopes are strongest, and in these places seedlings may have to be hand planted. Roads and skid trails should follow the contour and should not be located where the slopes are strongest. Areas that have lost their original cover need to be protected by seeding grass, planting trees, or mulching.

White pine, red oak, white oak, aspen, and beech are the native species to be favored. Scotch pine for Christmas trees is the only species commonly planted. Potential productivity is high to very high for pine, medium to high for aspen, medium for oak, and low to medium for mixed hardwoods.

WOODLAND SUITABILITY GROUP F

This group consists of somewhat poorly drained to poorly drained soils of the Au Gres, Gladwin, and Saugatuck series. These soils have a low available water capacity and low fertility. They all have a fluctuating high water table. The Saugatuck soil has a cemented subsoil, and one Au Gres soil has clayey underlying material at a depth of 42 to 66 inches. The slope range is 0 to 6 percent.

The erosion hazard is slight to moderate. Seedling mortality is moderate to severe. Plant competition and the hazards of insect and disease damage are moderate. Root development is restricted by the water table and by the hardpan in the Saugatuck soils; consequently, the windthrow hazard is moderate, and special management practices are needed to prevent loss of trees after openings have been made in the stand. The equipment limitation is moderate; machinery can be used without restriction only when the soils are dry or frozen.

Aspen, soft maple, white pine, white birch, and pin oak are the native species to be favored. Aspen growing on the Au Gres and Saugatuck soils is severely affected by hypoxylon canker. White pine, white spruce, and Norway spruce are the species most commonly planted. Potential productivity is low to medium for pine, aspen, and birch and very low for oak and mixed hardwoods.

WOODLAND SUITABILITY GROUP G

This group consists of somewhat poorly drained soils of the Allendale, Belding, Iosco, Kibbie, Matherton, Metamora, Richter, and Wasepi series. These soils have a low available water capacity and low to medium fertility. They all have a fluctuating high water table that is near the surface in spring and during wet weather in other seasons. The slope range is 0 to 6 percent.

The erosion hazard is slight. The equipment limitation is slight to moderate; equipment can be used without restriction only when the soils are dry or frozen. The hazards of insect and disease damage are moderate. The windthrow hazard is moderate; special management practices are needed to prevent excessive losses. Plant competition is moderate to severe, and seedling mortality is severe.

White ash, red maple, swamp white oak, cottonwood, and aspen are the native species to be favored. White spruce, white pine, and Norway spruce are the species most commonly planted. Potential productivity is low for oak and mixed hardwoods and low to medium for aspen and birch.

WOODLAND SUITABILITY GROUP H

This group consists of well-drained soils of the Deer Park, Kalkaska, and Rubicon series. These soils are sandy and droughty. They have a very low to low available water

capacity and very low to low fertility. The slope range is 0 to 45 percent.

Plant competition and the windthrow hazard are slight. Seedling mortality and the hazards of insect and disease damage are moderate. The erosion hazard and the equipment limitation are moderate to severe. For the Kalkaska and Rubicon soils, the erosion hazard varies with the slope, but for the Deer Park soils, it is severe regardless of slope. Removal of any vegetation from the Deer Park soils should be avoided. Roads, skid trails, and loading areas should be located where the risk of further erosion is least severe; they should not be on the stronger slopes or on any part of the Deer Park soils. Special care is needed to prevent destruction of the natural litter in drainageways. Areas from which the original vegetation has been removed need to be protected from erosion by seeding grass, planting trees, or mulching.

White pine, red pine, white oak, and black oak are the native species to be favored. Red pine, white pine, and jack pine are the species most commonly planted. Scotch pine is grown for Christmas trees only. Potential productivity is very low for oak and mixed hardwoods and medium to high for pine.

WOODLAND SUITABILITY GROUP K

This group consists of moderately well drained to well drained soils of the Fox, Hillsdale, and Tuscola series. The available water capacity of the Fox and Hillsdale soils is moderate, and that of the Tuscola soil is high. All the soils have medium fertility. The slope range is 0 to 12 percent.

Seedling mortality, the equipment limitation, the hazards of insect and disease damage, and the windthrow hazard are all slight. The erosion hazard is slight to moderate, depending on the slope. On slopes of 6 percent or more, wheel tracks more than 100 feet long tend to develop into gullies. Plant competition is moderate; brush and weeds delay adequate restocking after cutting. Logging causes some damage to tree roots.

Red oak, white ash, basswood, white oak, sugar maple, black walnut, and black cherry are the native species to be favored. White pine, white spruce, Norway spruce, Austrian pine, red pine, and black walnut are the species most commonly planted. Potential productivity is high for oak and high to very high for pine and for hardwoods.

WOODLAND SUITABILITY GROUP M

This group consists of well-drained soils of the Boyer and Oshtemo series. These soils have a low available water capacity and low fertility. The slope range is 0 to 18 percent.

The equipment limitation, the hazards of insect and disease damage, and the windthrow hazard are all slight. The erosion hazard is slight where the slope is no more than 12 percent and moderate where it is between 12 and 18 percent. On the stronger slopes all roads should follow the contour and loading areas should be protected from erosion. Seedling mortality and plant competition are slight to moderate. Although plant competition is not a serious problem, brush control is beneficial.

Oak, sugar maple, basswood, and beech are the native species to be favored. White pine, red pine, white spruce, jack pine, and black walnut are the species most commonly planted. Scotch pine is grown for Christmas trees only. Potential productivity is low to medium for oak and mixed hardwoods and medium to high for pine.

WOODLAND SUITABILITY GROUP O

This group consists of somewhat poorly drained to very poorly drained soils of the Algansee, Ceresco, Cohoctah, Glendora, Shoals, and Sloan series. All these soils are flooded for varying lengths of time in spring and after prolonged rain in other seasons. The Cohoctah, Glendora, and Sloan soils have a high water table and are saturated much of the year. Fertility and the available water capacity range from low to high. The slope range is 0 to 6 percent.

The erosion hazard is slight, and the hazard of damage by insects and diseases is moderate. The windthrow hazard is moderate to severe; trees released on all sides are likely to be blown down when the soils are flooded and the wind is high. Plant competition is moderate to severe; it delays and sometimes prevents the reestablishment of a stand by natural reseeding. Seedling mortality also is moderate to severe; germination of seed and growth of seedlings are slowed or prevented by excessive wetness and flooding, and special site preparation, along with control of competing vegetation, is needed to insure the survival of enough seedlings. The equipment limitation is severe, mainly because of flooding and excessive wetness; tree roots can be damaged by the use of equipment when the soils are wet.

White ash, red maple, basswood, and sycamore are the native species to be favored. Cottonwood and sycamore are the species most commonly planted. No ratings of potential productivity have been established.

WOODLAND SUITABILITY GROUP P

This group consists of poorly drained soils of the Hettinger, Sims, Toledo, and Washtenaw series. These soils have a high available water capacity and high fertility. They also have a high water table. The slope range is 0 to 4 percent.

The erosion hazard is slight, and the hazards of insect and disease damage are moderate. Plant competition is moderate to severe; it delays restocking by natural regeneration. Seedling mortality is severe, but such large numbers of natural seedlings are produced that stands are restocked in spite of the losses. The high water table restricts the development of tree roots, and consequently the hazard of windthrow is severe. The equipment limitation is severe because the soils are saturated much of the year.

Soft maple, white ash, and basswood are the native species to be favored. White spruce, Norway spruce, and white pine are the species most commonly planted. Potential productivity is low for oak and mixed hardwoods.

WOODLAND SUITABILITY GROUP Q

This group consists of very poorly drained to poorly drained soils of the Granby series. These soils have a low available water capacity and low fertility. They also have a high water table and are saturated much of the year. The slope range is 0 to 2 percent.

The erosion hazard is slight. Plant competition and the hazards of insect and disease damage are moderate. The equipment limitation is moderate to severe; the use of machinery is limited to periods when the soils are dry

or frozen. Careless use of equipment can damage tree roots. The windthrow hazard is severe; special patterns of harvesting are necessary to prevent excessive losses. Seedling mortality is severe.

Soft maple, white ash, pin oak, and white birch are the native species to be favored. Tree planting is not normally undertaken. Potential productivity is very low for pine and birch and low to very low for mixed hardwoods.

WOODLAND SUITABILITY GROUP U

This group consists of very poorly drained to poorly drained soils of the Adrian, Carlisle, Edwards, Houghton, Linwood, Wallkill, and Warners series; it also includes one land type, Marsh. All of these soils have a high available water capacity and low fertility. The water table is at or near the surface most of the year unless lowered by artificial drainage. The slope range is 0 to 3 percent.

The erosion hazard is slight; the hazards of insect and disease damage are moderate; and seedling mortality, plant competition, the equipment limitation, and the windthrow hazard are severe.

Soft maple, white-cedar, and willow are the native species to be favored. Generally, trees are planted on these soils only for windbreaks; the species commonly used in windbreaks are Austrian pine, white pine, Scotch pine, and willow. Establishing trees by planting is very difficult. No ratings of potential productivity have been established.

WOODLAND SUITABILITY GROUP W

This group consists of very poorly drained to poorly drained soils of the Breckenridge, Brevort, Bruce, Gilford, Lacota, Pinconning, and Tonkey series. The available water capacity and the fertility of these soils vary. The water table is high. The slope range is 0 to 6 percent.

The erosion hazard is slight, and the hazards of insect and disease damage are moderate. The high water table restricts the development of tree roots, and consequently the hazard of windthrow is moderate to severe. Seedling mortality and plant competition are severe; intensive preparation for planting is necessary. The equipment limitation is severe because of the high water table. Careless use of equipment can damage tree roots.

White ash, soft maple, and basswood are the native species to be favored. Tree planting is not normally undertaken. Potential productivity is very low for pine and very low to low for mixed hardwoods.

WOODLAND SUITABILITY GROUP Y

This group consists of five miscellaneous land types that represent sandy soils that are severely eroded and are still actively eroding. The available water capacity is low, and fertility is low. The slope range is 0 to 50 percent.

Plant competition is slight, the hazards of insect and disease damage are slight, the windthrow hazard is slight, seedling mortality is moderate to severe, and the equipment limitation is slight to severe, depending on the slope.

Reforesting these areas is difficult. First the soil material has to be stabilized by planting beachgrass, by mulching, or in some other way. Red pine (fig. 12), white pine, or jack pine can be planted after an area has been stabilized. One of the land types, Lake beaches, does not ordinarily support trees.

Figure 12.—**Stand of red pine, 14 years old, in a stabilized area of Blown-out land, which is in woodland suitability group Y.**

WOODLAND SUITABILITY GROUP Z

This group consists of somewhat poorly drained soils of the Blount, Bowers, Conover, Kawkawlin, and Selkirk series. The available water capacity of the Selkirk soils is moderate, and that of the other soils in the group is high. Fertility is high. The water table is near the surface in spring and during wet weather in other seasons. The slope range is 0 to 6 percent.

The erosion hazard is slight, the hazard of insect and disease damage is moderate, and the windthrow hazard is moderate. The equipment limitation is moderate also, because the soils are wet much of the year. Seedling mortality is moderate to severe because of the high water table; special preparation of sites for planting is needed. Plant competition is moderate to severe; to make sure of an adequate stand of the desired trees, chemical and mechanical means must be used to eliminate competing vegetation. The windthrow hazard is moderate.

White oak, red oak, basswood, soft maple, white ash, and cottonwood are the native species to be favored. White spruce, white pine, and white-cedar are the species commonly planted. Potential productivity is very low for pine and low to medium for oak and mixed hardwoods.

Wildlife [5]

Table 3 shows the relative suitability of the soils of Ottawa County for eight elements of wildlife habitat and for three general kinds of wildlife. The ratings given in this table are based on soil properties only. Present land use,

[5] By CHARLES M. SMITH, biologist, Soil Conservation Service.

TABLE 3.—*Suitability of soils for elements*

["Well suited" means the soils have no limitations that cannot easily be overcome; "suited" means limitations need to be recognized but wildlife habitat is questionable; "not suited" means extreme measures would be needed to

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood woody plants
Adrian: Ad, Ah For Houghton part of Ah, see Houghton series.	Not suited	Poorly suited	Poorly suited	Poorly suited
Algansee: Ak	Suited	Suited	Well suited	Suited
Allendale: AlA	Suited	Suited	Well suited	Suited
Au Gres: AmB, ArB, AsB For Saugatuck part of AsB, see Saugatuck series.	Not suited	Poorly suited	Poorly suited	Poorly suited
Belding: BeA, BeB	Suited	Suited	Well suited	Suited
Blount: BlA, BlB	Suited	Suited	Well suited	Suited
Blown-out land: BoB, BoF. Onsite investigation needed.				
Bowers: BpA, BpB	Suited	Suited	Well suited	Suited
Boyer: BrA, BrB, BrC	Suited	Well suited	Well suited	Well suited
Breckenridge: Bu	Poorly suited	Suited	Suited	Suited
Brevort: Bv	Poorly suited	Suited	Suited	Suited
Bruce: By	Poorly suited	Suited	Suited	Suited
Carlisle: Cc	Not suited	Poorly suited	Poorly suited	Poorly suited
Ceresco: Ce	Suited	Suited	Well suited	Suited
Chelsea: ChB, ChC, ClB	Not suited	Poorly suited	Poorly suited	Poorly suited
Cohoctah: Cm	Poorly suited	Suited	Suited	Suited
Conover: CnB	Suited	Suited	Well suited	Suited
Croswell: CrB, CwB For Au Gres part of CwB, see Au Gres series.	Not suited	Poorly suited	Poorly suited	Poorly suited
Deer Park: DpB, DpD, DpF	Not suited	Poorly suited	Poorly suited	Poorly suited
Edwards: Ed	Not suited	Poorly suited	Poorly suited	Poorly suited
Fox: FoB	Well suited	Well suited	Well suited	Well suited
Gilford: Gd	Poorly suited	Suited	Suited	Suited
Gladwin: GeA, GeB	Suited	Suited	Well suited	Suited
Glendora: Gl	Poorly suited	Suited	Suited	Suited
Granby: Gm, Gn	Not suited	Poorly suited	Poorly suited	Poorly suited
Gravel pits: Gr. Onsite investigation needed.				
Hettinger: Hg	Poorly suited	Suited	Suited	Suited
Hillsdale: HlB	Well suited	Well suited	Well suited	Well suited
HlC	Suited	Well suited	Well suited	Well suited
Houghton Mapped only with Adrian soils.	Not suited	Poorly sutied	Poorly suited	Poorly suited
Iosco: IoA, IrA, IsB For Allendale part of IrA, see Allendale series. For Belding part of IsB, see Belding series.	Suited	Suited	Well suited	Suited

existing vegetation, and artificial drainage were disregarded because they are subject to change. The ability of wildlife to move about from place to place was disregarded in establishing the ratings for the three kinds of wildlife. Explanations of the ratings are given in the headnote of the table.

Each soil is rated as not suited, poorly suited, suited, or well suited for each of the following:

Grain and seed crops.—In this group of plants are corn, wheat, oats, barley, buckwheat, millet, sorghum, soybeans, and sunflowers.

Grasses and legumes.—In this group are some of the common planted forage plants. Examples are bromegrass, fescue, timothy, redtop, trefoil, orchardgrass, reed canarygrass, clover, alfalfa, and sudangrass.

Wild herbaceous upland plants.—In this group are native annuals and perennials. Examples are strawberries, dandelions, goldenrod, wild oats, nightshade, ragweed, lambsquarters, and native grasses.

Hardwood woody plants.—In this group are trees and shrubs, both native and planted, that grow vigorously and produce food for wildlife in the form of sprouts, fruits, or seeds. Examples are maple, beech, oak, poplar, birch, dogwood, willow, hawthorn, viburnum, wintergreen, raspberries, blackberries, cherries, grapes, and blueberries.

Coniferous woody plants.—In this group are native and planted trees and shrubs. Examples are pine, spruce, white-cedar, hemlock, balsam fir, yew, larch, and juniper.

Wetland plants for food and cover.—In this group are plants that provide food and cover for waterfowl and for furbearing animals. Examples are cattails, sedges, bulrushes, smartweed, wild millet, water plantain, wildrice,

of wildlife habitat and for kinds of wildlife

can be overcome through good management and careful design; "poorly suited" means limitations are severe, and the use of the soils for overcome limitations, and use of the soils for wildlife habitat is generally unsound or impractical]

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous woody plants	Wetland plants for food and cover	Shallow water developments	Excavated ponds	Openland wildlife	Woodland wildlife	Wetland wildlife
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Poorly suited	Poorly suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Well suited	Poorly suited	Poorly suited	Suited	Suited	Suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Suited	Well suited	Poorly suited	Poorly suited	Suited	Suited	Suited.
Well suited	Not suited	Well suited	Well suited	Poorly suited	Poorly suited	Poorly suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.

TABLE 3.—*Suitability of soils for elements*

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood woody plants
Kalkaska: KaC	Not suited	Poorly suited	Poorly suited	Poorly suited
Kawkawlin: KnA, KnB	Suited	Suited	Well suited	Suited
Kibbie: KoA, KoB	Suited	Suited	Well suited	Suited
Lacota: La	Poorly suited	Suited	Suited	Suited
Lake beaches: Lb. Onsite investigation needed.				
Linwood: Ls	Not suited	Poorly suited	Poorly suited	Poorly suited
Made land: Ma. Onsite investigation needed.				
Mancelona: McA, McB, McC	Suited	Suited	Well suited	Well suited
Marsh: Me	Not suited	Not suited	Not suited	Not suited
Matherton: MhA	Suited	Suited	Well suited	Suited
Menominee: MmB, MmC	Suited	Well suited	Well suited	Well suited
Metamora: MnA, MnB	Suited	Suited	Well suited	Suited
Miami:				
MoB	Well suited	Well suited	Well suited	Well suited
MoC	Suited	Well suited	Well suited	Well suited
MoD	Poorly suited	Suited	Well suited	Well suited
MoF	Not suited	Poorly suited	Well suited	Well suited
Montcalm: MrA, MrB, MrC	Suited	Well suited	Well suited	Well suited
Morley:				
MtB	Well suited	Well suited	Well suited	Well suited
MtC2	Suited	Well suited	Well suited	Well suited
MtE2, MuD3	Poorly suited	Suited	Well suited	Well suited
MuF3	Not suited	Poorly suited	Well suited	Well suited
Nester:				
NeB	Well suited	Well suited	Well suited	Well suited
NeC, NsC3	Suited	Well suited	Well suited	Well suited
NeD, NsD3	Poorly suited	Suited	Well suited	Well suited
NeE, NeF, NsE3, NsF3	Not suited	Poorly suited	Well suited	Well suited
Newaygo: NwB	Suited	Well suited	Well suited	Well suited
Oshtemo:				
OsA, OsB, OsC	Suited	Well suited	Well suited	Well suited
OsD	Poorly suited	Suited	Well suited	Well suited
Owosso: OwB	Well suited	Well suited	Well suited	Well suited
Pinconning: Pn, Pr	Poorly suited	Suited	Suited	Suited
For Breckenridge part of Pr, see Breckenridge series.				
Richter: RcA, RcB	Suited	Suited	Well suited	Suited
Rubicon: RsB, RsD, RsF	Not suited	Poorly suited	Poorly suited	Poorly suited
Sand pits: Sd. Onsite investigation needed.				
Saugatuck	Not suited	Poorly suited	Poorly suited	Poorly suited
Mapped only with Au Gres soils.				
Selkirk: SeA, SeB	Suited	Suited	Well suited	Suited
Shoals: Sh	Suited	Suited	Well suited	Suited
Sims: Sm	Poorly suited	Suited	Suited	Suited
Sloan: Sn	Poorly suited	Suited	Suited	Suited
Spinks:				
SpA, SpB, SpC	Suited	Well suited	Well suited	Well suited
SsD, SsE	Poorly suited	Suited	Well suited	Well suited
SsF	Not suited	Poorly suited	Well suited	Well suited
For Montcalm part of SsD, SsE, and SsF, see Montcalm series.				
Toledo: Tc	Poorly suited	Suited	Suited	Suited
Tonkey: To	Poorly suited	Suited	Suited	Suited
Tuscola: TsB	Well suited	Well suited	Well suited	Well suited
Ubly:				
UlA, UlB	Well suited	Well suited	Well suited	Well suited
UlC	Suited	Well suited	Well suited	Well suited
Wallkill: Wa	Not suited	Poorly suited	Poorly suited	Poorly suited
Warners: Wm	Not suited	Not suited	Not suited	Not suited
Wasepi: WsA	Suited	Suited	Well suited	Suited
Washtenaw: Wt	Poorly suited	Suited	Suited	Suited
Wind eroded land, sloping: WuC	Not suited	Not suited	Poorly suited	Not suited

of wildlife habitat and for kinds of wildlife—Continued

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous woody plants	Wetland plants for food and cover	Shallow water developments	Excavated ponds	Openland wildlife	Woodland wildlife	Wetland wildlife
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Suited	Not suited.
Not suited	Well suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Suited	Suited	Suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Poorly suited	Poorly suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Suited	Well suited	Poorly suited	Poorly suited	Suited	Suited	Suited.
Suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Suited	Not suited	Not suited	Not suited	Suited	Well suited	Not suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Poorly suited	Poorly suited	Poorly suited	Well suited	Well suited	Poorly suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Not suited	Well suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.

arrowhead, pondweed, pickerelweed, wildcelery, duckweed, and burreed.

Shallow water developments.—These are impoundments in marshy areas and stream channels. Examples of the structures that may be used are low dikes, nearly level ditches, dugouts, and devices for controlling the depth of the water so as to maintain a habitat suitable for wetland wildlife.

Excavated ponds.—Ponds of this kind should have an independent source of water; they should not depend on runoff, although runoff may be beneficial if it is not excessive. Such ponds attract migrating waterfowl.

Openland wildlife.—In this group of wildlife are birds and mammals that normally frequent cropland, pastures, meadows, and areas overgrown with grasses, herbs, and shrubs. Examples are quail, pheasant, meadowlarks, field sparrows, red foxes, cottontail rabbits, woodchucks, and hawks.

Woodland wildlife.—In this group are birds and mammals that frequent areas that have a cover of hardwood trees, coniferous trees, shrubs, or mixtures of these. Examples are squirrels, raccoons, ruffed grouse, woodcock, woodpeckers, warblers, nuthatches, deer, gray foxes, and owls.

Wetland wildlife.—In this group are birds and mammals that inhabit ponds, marshes (fig. 13), and swamps. Examples are muskrats, ducks, geese, herons, rails, kingfishers, mink, cranes, and bitterns.

Engineering Uses of the Soils [6]

This section will be of special interest to engineers, contractors, farmers, and others who use soils as structural or foundation material. Tables 4, 5, and 6 describe and interpret soil properties that affect the construction and maintenance of roads and airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, and sewage disposal systems. Among the soil properties significant in engineering are permeability, shear strength, density, shrink-swell potential, available water capacity, grain-size distribution, plasticity, and reaction.

The information given in this section can be used in—

1. Planning and designing agricultural drainage systems, farm ponds, irrigation systems, diversion terraces, and other structures for controlling water and conserving soil.
2. Selecting potential locations for highways, airports, pipelines, and underground cables.
3. Locating probable sources of sand or gravel suitable for use as construction material.
4. Selecting potential industrial, commercial, residential, and recreational areas.

The data and interpretations reported here do not eliminate the need for sampling and testing the soils at the site of a specific engineering work involving heavy loads or excavations deeper than the depths of the layers here described. Even in such a situation, however, this section and the soil map are useful in that they indicate the kinds of problems that can be expected and provide a basis for planning detailed field investigations.

[6] HOMER D. MCGHIE, agricultural engineer, Soil Conservation Service, helped prepare this section.

Some terminology used by soil scientists may be unfamiliar to engineers, and some words have different meanings in soil science than in engineering. Among the words that have special meanings in soil science are the following: gravel, sand, silt, clay, surface layer, subsoil, and horizon. These and other special terms are defined in the Glossary at the back of this publication.

Engineering classification systems

Two systems of classifying soils for engineering purposes are in general use. One was developed by the American Association of State Highway Officials (AASHO) and is commonly used by highway engineers. The other, known as the Unified system, was developed by the U.S. Army Corps of Engineers. It is the one generally used by the Soil Conservation Service engineers.

In the AASHO system (*1*), each soil is placed in one of seven basic groups, on the basis of grain-size distribution, liquid limit, and plasticity index. The groups are numbered A–1 through A–7. In group A–1 are gravelly soils of high bearing strength, the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and are the poorest soils for subgrade. If engineering test data are available, groups A–1, A–2, and A–7 can be subdivided. Also provided that test data are available, the relative engineering values of soils within one group can be indicated by group index numbers, which range from 0 for the best soils in the group to 20 for the poorest. The group index number, if one has been determined, is added in parentheses to the group symbol, in this manner: A–1(0).

In the Unified system (*10*), each soil is placed in one of 15 groups, according to particle-size distribution, plasticity liquid limit, and organic-matter content. There are eight classes of coarse-grained soils, identified by the symbols GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified by the symbols ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified by the symbol Pt.

Table 4 gives estimated engineering classifications, according to both systems, for all the soils of Ottawa County. It does not give the subdivisions of the basic groups or the group indexes that are part of the AASHO system, because these can be determined only by laboratory tests. Table 4 also gives the USDA textural classifications of all the soils. In the USDA system (*8*), the classifications are based on the proportions of sand, silt, and clay particles.

Estimated engineering properties of the soils

Table 4 gives estimates of selected soil properties that are significant in engineering and estimates of the AASHO and Unified classifications of the soils. In general, these estimates reflect the properties of the soils to a depth of 5 feet or less. They do not take the place of detailed onsite investigation. Explanations of the columns in table 4 follow.

Depth to seasonal high water table is estimated on the assumption that no artificial drainage is in effect. During prolonged periods of wet weather or of extremely dry weather, the depth to the water table is likely to be outside the range given in the table.

Depth from surface refers to the upper and lower levels of the major horizons, in terms of inches below the surface.

Figure 13.—An area of Marsh; suitable habitat for wetland wildlife.

Brief explanations of the USDA textural classification and of the two engineering classifications, along with references to publications in which these are explained in greater detail, are given in the section headed "Engineering classification systems."

The percentages passing the various sized sieves are estimates rounded to the nearest 5 percent. The percentage that passes through the No. 200 sieve approximates the amount of silt and clay particles in the soil. The larger percentages that pass through the No. 10 and No. 4 sieves include coarser particles as well as the silt and clay particles.

Permeability refers to the rate at which water moves downward through the undisturbed soil. The estimates are based mainly on the texture, structure, and consistence of the soil.

Available water capacity refers to the capacity of a soil, to a depth of 60 inches, to store water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at the wilting point.

Reaction refers to the degree of acidity or alkalinity of a soil; it is expressed as a range in pH value. A value of 7 indicates a neutral reaction; a lower value indicates an acid reaction, and a higher one an alkaline reaction. The pH values given in table 4 are field estimates.

Shrink-swell potential is an indication of the change in volume to be expected if the moisture content of a soil changes. The estimates are based mainly on the amount and kind of clay in a soil.

No estimates of depth to bedrock are given in table 4, because all the soils are deep enough that bedrock does not interfere with engineering operations.

Engineering interpretations

Table 5 contains interpretations of the soil properties presented in table 4, in relation to road building and community development. Explanations of the columns in table 5 follow.

The ratings for topsoil refer to suitability for use as topdressing on back slopes, embankments, lawns, and gardens. These ratings depend mainly on texture and organic-matter content. Unless otherwise indicated, only the surface layer of a mineral soil is considered suitable.

TABLE 4.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table [1]	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Adrian: Ad, Ah	0	0–20	Muck and peat
		20–60	Loamy sand and sand
For Houghton part of Ah, see Houghton series.			
Algansee: Ak	[2] 1–2	0–10	Loamy sand
		10–60	Sand
Allendale: AlA	1–2	0–12	Sandy loam and loamy sand
		12–34	Loamy sand
		34–39	Sandy clay
		39–60	Silty clay
Au Gres:			
AmB, AsB	1–2	0–8	Loamy sand and sand
		8–66	Sand
For Saugatuck part of AsB, see Saugatuck series.			
ArB	1–2	0–54	Loamy sand and sand
		54–66	Clay loam and silty clay loam
Belding: BeA, BeB	1–2	0–11	Sandy loam
		11–24	Sandy loam and loamy sand
		24–66	Clay loam and sandy clay loam
Blount: BlA, BlB	1–2	0–12	Loam
		12–25	Clay loam and heavy clay loam
		25–50	Clay loam
Blown-out land: BoB, BoF. No estimates of properties. Onsite investigation needed.			
Bowers: BpA, BpB	1–2	0–7	Loam
		7–20	Fine sandy loam and clay loam
		20–29	Silty clay loam
		29–50	Silty clay loam and a few thin layers of silt loam
Boyer: BrA, BrB, BrC	4+	0–6	Loamy sand
		6–30	Sand
		30–36	Gravelly sandy loam
		36–66	Sand and gravel
Breckenridge: Bu	<1	0–14	Sandy loam
		14–35	Sandy loam and loamy sand
		35–50	Clay loam and silty clay loam
Brevort: Bv	<1	0–8	Light sandy loam
		8–32	Loamy sand
		32–50	Clay loam
Bruce: By	<1	0–14	Loam and silt loam
		14–24	Light silty clay loam
		24–50	Stratified silt loam
Carlisle: Cc	0	0–60	Muck and peat
Ceresco: Ce	1–2	0–12	Sandy loam
		12–60	Sandy loam and loamy fine sand
Chelsea: ChB, ChC, ClB	4+	0–7	Loamy sand
		7–48	Sand
		48–66	Stratified sand and sandy loam
Cohoctah: Cm	[2] <1	0–13	Loam
		13–50	Stratified loam and sandy loam
Conover: CnB	1–2	0–13	Loam
		13–29	Clay loam
		29–60	Heavy loam

See footnotes at end of table.

properties of the soils

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH*	
Pt					6. 3–20. 0	0. 50	6. 6–7. 3	Variable.
SM or SP	A–2 or A–3	100	95–100	0–20	6. 3–20. 0	. 04	6. 6–8. 0	Low.
SM	A–2	100	100	15–20	6. 3–20. 0	. 12	5. 6 6. 0	Low.
SP or SP–SM	A–3	100	100	0–10	6. 3–20. 0	. 05	5. 6–7. 3	Low.
SM	A–2	100	95–100	15–25	6. 3–20. 0	. 10	5. 6–6. 0	Low.
SM	A–2	100	95–100	10–20	6. 3–20. 0	. 06	6. 1–6. 5	Low.
SC	A–7	100	95–100	40–50	0. 06–0. 2	. 14	6. 6–7. 3	High.
CH	A–7	95–100	90–100	75–95	0. 06–0. 2	. 14	[3] 7. 4–8. 0	High.
SP or SM	A–2 or A–3	100	95–100	0–20	6. 3–20. 0	. 06	5. 6–6. 0	Low.
SP or SP–SM	A–3	100	95–100	0–10	6. 3–20. 0	. 04	5. 1–6. 5	Low.
SP or SM	A–2 or A–3	100	95–100	0–20	6. 3–20. 0	. 06	5. 6–6. 0	Low.
CL	A–6 or A–7	95–100	90–100	70–85	0. 2–0. 63	. 16	7. 4–8. 0	Moderate.
SM	A–2	95–100	95–100	15–35	2. 0–6. 3	. 12	5. 6–6. 0	Low.
SM	A–2	95–100	95–100	15–35	2. 0–6. 3	. 10	5. 1–6. 0	Low.
CL or SC	A–6	85–95	80–95	40–90	0. 2–0. 63	. 16	[3] 6.1–8. 0	Moderate.
ML	A–4	95–100	95–100	55–70	0. 63–2. 0	. 18	5. 1–6. 0	Low.
CL	A–6 or A–7	95–100	95–100	70–85	0. 2–0. 63	. 16	5. 0–6. 5	Moderate.
CL	A–6	90–95	85–95	70–80	0. 2–0. 63	. 16	[3] 7. 4–8. 0	Moderate.
ML–CL	A–4	100	100	60–75	0. 63–2. 0	. 22	6. 1–6. 5	Low.
CL or ML	A–6 or A–4	100	100	50–80	0. 63–2. 0	. 18	6. 1–6. 5	Low.
ML–CL	A–7	100	100	85–95	0. 2–0. 63	. 16	6. 6–7. 3	Moderate.
CL	A–6	100	95–100	70–90	0. 63–2. 0	. 18	[3] 7. 4–8. 0	Moderate.
SM	A–2	95–100	95–100	15–30	6. 3–20. 0	. 10	5. 1–5. 5	Low.
SP or SP–SM	A–3	95–100	95–100	0–10	6. 3–20. 0	. 05	5. 6–6. 0	Low.
SM or SC	A–2 or A–4	75–85	70–80	30–45	6. 3–20. 0	. 12	5. 6–6. 0	Low.
SP–SM or SP	A–3 or A–1	55–80	50–70	0–10	6. 3–20. 0	. 02	[3] 7. 4–8. 0	Low.
SM	A–2 or A–4	100	95–100	25–50	2. 0–6. 3	. 12	5. 6–6. 5	Low.
SM	A–2	95–100	90–100	20–35	0. 63–2. 0	. 10	5. 6–7. 3	Low.
CL	A–6	95–100	90–100	70–85	0. 2–0. 63	. 16	[3] 7. 4–8. 0	Moderate.
SM	A–2	100	100	15–35	6. 3–20. 0	. 12	6. 6–7. 3	Low.
SM	A–2	95–100	95–100	15–30	6. 3–20. 0	. 07	5. 6–7. 3	Low.
CL	A–6	100	95–100	70–90	0. 2–0. 63	. 16	[3] 7. 4–8. 0	Moderate.
ML–CL	A–4	100	100	65–90	0. 63–2. 0	. 18	6. 6–7. 3	Low.
CL	A–6	100	100	80–95	0. 63–2. 0	. 18	7. 4–7. 8	Moderate.
ML and ML–CL	A–4	100	95–100	60–80	0. 63–2. 0	. 16	7. 4–7. 8	Low.
Pt					6. 3–20. 0	. 50	5. 6–6. 5	Variable.
SM	A–2	100	100	15–35	2. 0–6. 3	. 12	6. 6–7. 3	Low.
SM	A–2	100	100	15–25	2. 0–6. 3	. 10	6. 1–8. 0	Low.
SM	A–2	100	100	15–25	6. 3–20. 0	. 10	6. 6–7. 5	Low.
SP or SM	A–2 or A–3	100	100	0–15	6. 3–20. 0	. 03	5. 6–6. 5	Low.
SM	A–2	95–100	90–100	10–25	6. 3–20. 0	. 12	6. 1–6. 5	Low.
ML	A–4	100	100	55–70	0. 63–2. 0	. 21	7. 4–7. 8	Low.
SM or ML	A–4	100	100	35–55	0. 63–6. 3	. 15	7. 9–8. 0	Low.
ML	A–4	100	95–100	60–70	0. 63–2. 0	. 18	4. 5–7. 3	Low.
CL	A–6	95–100	95–100	65–80	0. 63–2. 0	. 18	5. 1–6. 5	Moderate.
ML–CL or CL	A–4 or A–6	90–95	85–95	60–80	0. 63–2. 0	. 16	[3] 7. 4–8. 0	Low to moderate.

TABLE 4.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table [1]	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Croswell: CrB, CwB For Au Gres part of CwB, see AmB and AsB under Au Gres series.	2–3	0–60	Sand
Deer Park: DpB, DpD, DpF	6+	0–66	Sand
Edwards: Ed	0	0–30 30–60	Muck and peat Marl
Fox: FoB	4+	0–12 12–38 38–60	Sandy loam and loamy sand Gravelly sandy clay loam and heavy sandy loam Gravel and coarse sand
Gilford: Gd	<1	0–12 12–31 31–66	Sandy loam Sandy loam and loamy sand Sand and gravel
Gladwin: GeA, GeB	1–2	0–11 11–17 17–26 26–60	Sandy loam and loamy sand Loamy sand Gravelly sandy loam Coarse sand and gravel
Glendora: Gl	[2] <1	0–10 10–25 25–50	Sandy laom Loamy sand Sand
Granby: Gm, Gn	<1	0–10 10–60	Loamy sand Sand
Gravel pits: Gr. No estimates of properties. Onsite investigation needed.			
Hettinger: Hg	<1	0–11 11–32 32–50	Loam and silt loam Silty clay loam Silty clay loam and thin layers of silt
Hillsdale: HlB, HlC	4+	0–11 11–23 23–78	Sandy loam Sandy loam and sandy clay loam Sandy loam
Houghton Mapped only in a complex with Adrian soils.	0	0–60	Muck over peat
Iosco: IoA, IrA, IsB For Allendale part of IrA, see Allendale series. For Belding part of IsB, see Belding series.	1–2	0–31 31–60	Loamy sand and sand Clay loam and silty clay loam
Kalkaska: KaC	4+	0–7 7–66	Sand Sand, weakly cemented in spots
Kawkawlin: KnA, KnB	1–2	0–7 7–24 24–50	Loam Loam and heavy clay loam Clay loam
Kibbie: KoA, KoB	1–2	0–10 10–30 30–50	Loam Silt loam Silt and very fine sand
Lacota: La	<1	0–14 14–38 38–66	Silt loam Light silty clay loam and silt loam Sand and fine gravel
Lake beaches: Lb. No estimates of properties. Onsite investigation needed.			

See footnotes at end of table.

properties of the soils—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH*	
SP–SM	A–3	100	95–100	5–10	6. 3–20. 0	0. 04	4. 5–6. 0	Low.
SP or SP–SM	A–3 or A–1	100	95–100	0–10	6. 3–20. 0	. 02	5. 6–6. 5	Low.
Pt					6. 3–20. 0	. 50	5. 6–7. 3	Variable.
					(4)	. 18	(3)	Variable.
SM	A–2 or A–4	95–100	95–100	25–45	2. 0–6. 3	. 12	5. 1–6. 0	Low.
SC or SM–SC	A–6 or A–4	75–85	70–80	35–50	0. 63–2. 0	. 16	5. 6–6. 5	Moderate.
GP or SP	A–1	40–80	35–70	0–5	>20. 0	. 02	6. 6–7. 3	Low.
SM	A–2 or A–4	95–100	95–100	25–45	2. 0–6. 3	. 14	6. 1 6. 5	Low.
SM	A–2	95–100	90–100	20–35	0. 63–2. 0	. 10	5. 6–6. 5	Low.
SP or SP–SM	A–3	55–80	50–70	0–10	6. 3–20. 0	. 02	6. 1–7. 8	Low.
SM	A–2	95–100	95–100	15–30	2. 0–6. 3	. 14	5. 6–6. 0	Low.
SM	A–2	95–100	95–100	15–25	6. 3–20. 0	. 05	6. 1–6. 5	Low.
SM or SC	A–2 or A–6	75–85	70–80	30–45	0. 63–2. 0	. 10	6. 6–7. 3	Low.
SP–SM or SP	A–3	55–80	50–70	0–10	>20. 0	. 02	(3) 7. 4–8. 0	Low.
SM	A–2	100	100	15–30	6. 3–20. 0	. 14	6. 1–6. 5	Low.
SM	A–2	100	100	15–35	6. 3–20. 0	. 06	6. 6–7. 3	Low.
SP	A–3	100	95–100	0–5	6. 3–20. 0	. 04	7. 4–7. 8	Low.
SM	A 2	100	100	15–20	6. 3–20. 0	. 07	6. 6–7. 3	Low.
SP	A–3	100	100	0–5	6. 3–20. 0	. 04	6. 1–7. 3	Low.
ML	A–4	100	100	55–90	0. 63–2. 0	. 18	6. 6–7. 3	Low.
CL	A–6	100	100	80–95	0. 2–0. 63	. 16	(3) 7. 4–8. 0	Moderate.
ML–CL	A–6	100	95–100	70–95	0. 2–0. 63	. 16	(3) 7. 4–8. 0	Moderate.
SM	A–2 or A–4	95–100	95–100	25–45	2. 0 6. 3	. 12	4. 5–5. 5	Low.
SM, SC, or CL	A–2 or A–6	95–100	95–100	25–55	0. 63–2. 0	. 16	<4. 5	Low to moderate.
SM	A–2 or A–4	80–95	75–95	25–45	2. 0–6. 3	. 10	4. 0–6. 0	Low.
Pt					6. 3–20. 0	. 50	6. 1–7. 3	Variable.
SM or SP–SM	A–2 or A–3	95–100	95–100	5–30	6. 3–20. 0	. 04	5. 6–6. 5	Low.
CL	A–6 or A–7	85–100	80–100	60–85	0. 2–0. 63	. 18	(3) 7. 4–8. 0	Moderate.
SP	A–3	100	95–100	0–5	6. 3–20. 0	. 06	5. 6–6. 5	Low.
SP	A–3	100	95–100	0–5	6. 3–20. 0	. 04	5. 1–6. 5	Low.
ML	A–4	95–100	95–100	55–70	0. 63–2. 0	. 18	6. 6–7. 3	Low.
CL or ML	A–6	95–100	95–100	70–85	0. 2–0. 63	. 16	6. 6–7. 3	Moderate.
CL	A–6	90–95	85–95	70–85	0. 2–0. 63	. 16	(3) 7. 4–8. 0	Moderate.
ML or CL	A–4 or A–6	100	100	55–65	0. 63–2. 0	. 16	6. 6–7. 3	Low.
ML or CL	A–4 or A–6	100	100	60–90	0. 63–2. 0	. 18	6. 1–7. 8	Low.
ML or SM	A–4 or A–2	100	100	40–90	0. 63–2. 0	. 16	7. 9–8. 0	Low.
ML	A–4	100	95–100	60–70	0. 63–2. 0	. 20	6. 6–7. 8	Low.
CL	A–6	100	95–100	80–90	0. 63–2. 0	. 16	(3) 6. 6–8. 0	Low to moderate.
SP or SP–SM	A–3	55–80	50–70	0–10	6. 3–20. 0	. 06	(3) 7. 4–8. 0	Low.

TABLE 4.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table [1]	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Linwood: Ls	0	0–30	Muck and peat
		30–50	Loam
Made land: Ma. No estimates of properties. Onsite investigation needed.			
Mancelona: McA, McB, McC	4+	0–14	Loamy sand and sandy loam
		14–30	Loamy sand and sand
		30–34	Sandy clay loam
		34–66	Coarse sand and gravel
Marsh: Me. No estimates of properties. Onsite investigation needed.			
Matherton: MhA	1–2	0–10	Loam
		10–25	Sandy loam
		25–40	Sandy clay loam and gravelly clay loam
		40–66	Fine gravel and sand
Menominee: MmB, MmC	3+	0–22	Loamy sand
		22–32	Sand and a few thin layers of loamy sand
		32–66	Clay loam and sandy clay loam
Metamora: MnA, MnB	1–2	0–29	Sandy loam and loamy sand
		29–60	Sandy clay loam and silty clay loam
Miami: MoB, MoC, MoD, MoF	3+	0–10	Loam
		10–30	Light clay loam
		30–66	Loam
Montcalm: MrA, MrB, MrC	4+	0–14	Loamy sand
		14–48	Sand and thin layers of loamy sand and light sandy loam.
		48–60	Sandy loam
		60–66	Loamy sand
Morley: MtB, MtC2, MtE2, MuD3, MuF3	2–3+	0–6	Loam
		6–26	Clay loam and heavy clay loam
		26–50	Clay loam
Nester: NeB, NeC, NeD, NeE, NeF, NsC3, NsD3, NsE3, NsF3.	2–3+	0–14	Loam
		14–28	Heavy clay loam
		28–50	Clay loam
Newaygo: NwB	4+	0–30	Sandy loam
		30–40	Light clay loam
		40–66	Sand and gravel
Oshtemo: OsA, OsB, OsC, OsD	4+	0–36	Sandy loam and loamy sand
		36–50	Sandy loam and sandy clay loam
		50–66	Coarse sand
Owosso: OwB	3+	0–25	Sandy loam and loamy fine sand
		25–30	Sandy clay loam
		30–60	Clay loam
Pinconning: Pn, Pr. For Breckenridge part of Pr, see Breckenridge series.	<1	0–12	Sandy loam and loamy sand
		12–36	Sand
		36–50	Silty clay
Richter: RcA, RcB	1–2	0–20	Sandy loam and loamy sand
		20–50	Stratified fine sandy loam and loamy fine sand
Rubicon: RsB, RsD, RsF	4+	0–66	Sand

See footnotes at end of table.

properties of the soils—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH*	
Pt					6. 3–20. 0	0. 50	5. 1–6. 0	Variable.
CL or ML–CL	A–4 or A–6	95–100	90–100	60–90	0. 63–2. 0	. 14	5. 6–6. 0	Low.
SM	A–2	95–100	95–100	15–35	6. 3–20. 0	. 10	5–1. 6. 5	Low.
SM	A–2	95–100	95–100	10–20	6. 3–20. 0	. 06	5. 6–6. 0	Low.
SC	A–6	95–100	90–100	30–45	0. 63–2. 0	. 16	5. 6–6. 0	Moderate.
SP–SM or SP	A–1	55–80	50–70	0–10	>20. 0	. 02	[3] 7. 4–8. 0	Low.
ML	A–4	95–100	95–100	55–65	0. 63–2. 0	. 18	7. 4–7. 8	Low.
SM	A–2	95–100	80–95	25–35	2. 0–6. 3	. 14	6. 6–7. 8	Low.
SC or CL	A–6	75–85	70–80	35–65	0. 63–2. 0	. 16	6. 1–7. 3	Moderate.
GP or SP	A–1 or A–3	40–80	35–70	0–5	>20. 0	. 02	[3] 7. 4–8. 0	Low.
SM	A–2	95–100	95–100	10–30	6. 3–20. 0	. 10	5. 6–7. 3	Low.
SP or SP–SM	A–3	95–100	95–100	0–10	6. 3–20. 0	. 04	5. 6–6. 0	Low.
CL	A–6	100	95–100	50–90	0. 2–0. 63	. 18	[3] 6. 6–8. 0	Moderate.
SM	A–2	95–100	95–100	15–35	2. 0–6. 3	. 10	6. 1–7. 3	Low.
CL	A–6	95–100	90–100	50–90	0. 2–0. 63	. 16	[3] 7. 4–8. 0	Moderate.
ML–CL	A–4	100	95–100	60–70	0. 63–2. 0	. 16	5. 6–7. 3	Low.
CL	A–6	95–100	95–100	55–70	0. 63–2. 0	. 18	5. 6–6. 5	Moderate.
ML or CL	A–4 or A–6	90–95	85–95	55–70	0. 63–2. 0	. 16	[3] 7. 4–8. 0	Low to moderate.
SM	A–2	100	100	10–20	6. 3–20. 0	. 06	5. 6–7. 3	Low.
SM or SP–SM	A–2 or A–3	100	95–100	5–25	6. 3–20. 0	. 06	5. 6–6. 5	Low.
SM	A–2 or A–4	100	100	25–45	2. 0–6. 3	. 12	6. 1–6. 5	Low.
SP–SM or SP	A–2	100	100	10–20	6. 3–20. 0	. 06	5. 6–6. 0	Low.
ML	A–4	95–100	95–100	55–65	0. 63–2. 0	. 18	6. 6–7. 3	Low.
CL or CH	A–6 or A–7	95–100	95–100	70–90	0. 2–0. 63	. 18	5. 1–6. 0	Moderate to high.
ML or CL	A–6	90–95	85–95	70–85	0. 2–0. 63	. 18	[3] 7. 4–8. 0	Moderate.
ML	A–4	95–100	95–100	55–65	0. 63–2. 0	. 18	5. 1–5. 5	Low.
CL or CH	A–6 or A–7	95–100	95–100	70–85	0. 2–0. 63	. 18	6. 1–6. 5	Moderate to high.
CL	A–6	90–95	85–95	70–90	0. 2–0. 63	. 18	[3] 7. 4–8. 0	Moderate.
SM	A–2	90–100	85–95	20–35	2. 0–6. 3	. 12	5. 1–6. 0	Low.
SC or CL	A–6	80–90	70–85	45–60	0. 63–2. 0	. 16	6. 6–7. 3	Moderate.
GP or SP	A–1	30–60	20–60	0–5	>20. 0	. 02	[3] 7. 4–8. 0	Low.
SM	A–2	95–100	95–100	15–30	6. 3–20. 0	. 10	<4. 5–5. 5	Low.
SM or SC	A–2 or A–4	95–100	90–100	25–50	0. 63–2. 0	. 14	4. 5–5. 5	Low to moderate.
SP–SM or SP	A–1	90–100	85–95	0–10	6. 3–20. 0	. 02	5. 1–5. 5	Low.
SM	A–2	95–100	95–100	15–25	2. 0–6. 3	. 10	6. 1–7. 3	Low.
SC	A–2 or A–6	90–100	85–95	20–50	0. 63–2. 0	. 16	6. 6–7. 3	Moderate.
CL	A–6	95–100	90–100	70–85	0. 63–2. 0	. 18	7. 9–8. 0	Moderate.
SM	A–2 or A–4	100	95–100	15–45	2. 0–6. 3	. 10	6. 6–7. 3	Low.
SP–SM	A–3	100	95–100	5–10	6. 3–20. 0	. 04	6. 6–7. 3	Low.
CH or CL	A–7	95–100	90–100	80–100	0. 06–0. 2	. 18	[3] 7. 4–8. 0	High.
SM	A–2 or A–4	100	100	20–45	2. 0–6. 3	. 12	5. 6–6. 5	Low.
SM and ML	A–2 and A–4	100	95–100	20–60	0. 63–2. 0	. 12	6. 1–7. 8	Low.
SP	A–3	100	95–100	0–5	6. 3–20. 0	. 04	5. 1–6. 0	Low.

TABLE 4.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table [1]	Depth from surface	Classification: USDA texture
Sand pits: Sd. No estimates of properties. Onsite investigation needed.			
	Feet	*Inches*	
Saugatuck	<1–2	0–9	Fine sand and sand
		9–19	Cemented fine sand
Mapped only in a complex with Au Gres soils.		19–60	Fine sand
Selkirk: SeA, SeB	1–2	0–12	Loam and silty clay loam
		12–22	Silty clay
		22–50	Silty clay
Shoals: Sh	[2] 1–2	0–16	Silt loam and loam
		16–43	Silty clay loam
		43–60	Fine sandy loam
Sims: Sm	<1	0–9	Loam
		9–30	Clay loam and heavy clay loam
		30–50	Clay loam
Sloan: Sn	[2] <1	0–12	Loam
		12–42	Silt loam and light silty clay loam
		42–60	Loam
Spinks: SpA, SpB, SpC, SsD, SsE, SsF	4+	0–21	Loamy sand and sand
		21–58	Stratified sand and loamy sand
For Montcalm part of SsD, SsE, and SsF, see Montcalm series.		58–66	Loamy sand
Toledo: Tc	<1	0–12	Silty clay loam
		12–24	Silty clay
		24–60	Stratified silty clay loam and silty clay
Tonkey: To	<1	0–26	Sandy loam
		26–50	Stratified sandy loam and loamy fine sand
Tuscola: TsB	2–3	0–11	Fine sandy loam
		11–30	Stratified loam and silty clay loam
		30–50	Stratified silt loam and silt
Ubly: UlA, UlB, UlC	2–3+	0–21	Sandy loam and loamy fine sand
		21–38	Sandy clay loam
		38–60	Clay loam
Wallkill: Wa	[2] 0	0–24	Silt loam and silty clay loam
		24–60	Peat and muck
Warners: Wm	0	0–5	Muck
		5–60	Marl
Wasepi: WsA	1–2	0–12	Sandy loam
		12–26	Sandy loam
		26–50	Gravelly loamy sand, sand, and gravel
Washtenaw: Wt	<1	0–27	Loam
		27–50	Silt loam and clay loam
Wind eroded land, sloping: WuC. No estimates of properties. Onsite investigation needed.			

[1] Assuming no artificial drainage. [2] Subject to flooding. [3] Calcareous. [4] Variable.

properties of the soils—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH*	
SP	A-3	100	95–100	0–5	6. 3–20. 0	0. 06	4. 5–5. 0	Low.
SP or SP-SM	A-3	100	95–100	0–10	0. 06–0. 2	. 04	4. 5–5. 0	Low.
SP or SP-SM	A-3	100	95–100	0–10	6. 3–20. 0	. 04	4. 5–5. 5	Low.
ML-CL	A-4 or A-6	100	100	60–75	0. 63–2. 0	. 18	6. 6–7. 8	Moderate.
CH	A-7	100	100	80–90	0. 06–0. 2	. 14	7. 4–7. 8	High.
CH	A-7	100	95–100	80–95	0. 06–0. 2	. 14	[3] 7. 4–8. 0	High.
ML	A-4	100	100	60–90	0. 63–2. 0	. 20	7. 9–8. 0	Low.
ML-CL	A-6	100	100	80–90	0. 2–0. 63	. 18	7. 4–8. 0	Moderate.
SM	A-4	100	100	25–50	0. 63–2. 0	. 12	7. 9–8. 0	Low.
ML-CL	A-4	100	100	60–70	0. 63–2. 0	. 18	6. 6–7. 3	Moderate.
CL or CH	A-6 or A-7	100	100	70–90	0. 2–0. 63	. 18	7. 4–7. 8	Moderate to high.
CL	A-6	100	95–100	70–85	0. 2–0. 63	. 16	[3] 7. 4–8. 0	Moderate.
ML	A-4	100	95–100	55–65	0. 63–2. 0	. 18	6. 6–7. 3	Low.
ML-CL or ML	A-4 or A-6	100	95–100	75–90	0. 2–0. 63	. 18	7. 4–8. 0	Low to moderate.
ML-CL	A-4	100	100	60–90	0. 63–2. 0	. 16	7. 9 8. 0	Low.
SM	A-2	100	100	10–20	6. 3–20. 0	. 06	5. 6–6. 5	Low.
SM or SP-SM	A-2	100	100	10–25	6. 3–20. 0	. 06	5. 6–6. 0	Low.
SM	A-2	100	100	15–35	6. 3–20. 0	. 04	7. 4–7. 8	Low.
CL or CH	A-7	100	100	80 95	0. 2–0. 63	. 18	7. 4–7. 8	High.
CL or CH	A-7	100	100	80–95	0. 06–0. 2	. 14	7. 9–8. 0	High.
CL or CH	A-7	100	95–100	75–95	0. 06–0. 2	. 16	[3] 7. 9–8. 0	High.
SM	A-2	100	100	20–35	2. 0–6. 3	. 14	5. 6–6. 5	Low.
SM or ML	A-4	100	95–100	35–60	0. 63–2. 0	. 12	6. 1–7. 8	Low.
SM or ML	A-4	100	100	35–60	2. 0–6. 3	. 16	5. 1–6. 5	Low.
ML or CL	A-4 or A-6	100	100	55–90	0. 2–2. 0	. 18	4. 5–5. 5	Low to moderate.
ML	A-4	100	95–100	65–95	0. 63–2. 0	. 18	6. 6–8. 0	Low.
SM	A-2	95–100	95–100	15–35	2. 0–6. 3	. 12	5. 6–6. 5	Low.
CL or SC	A-6	100	95–100	35–55	0. 63–2. 0	. 16	5. 6–6. 0	Moderate.
CL	A-6	85–95	80–95	60–90	0. 2–0. 63	. 16	[3] 7. 4–8. 0	Moderate.
ML–CL or ML	A-4 or A-6	100	100	65–95	0. 63–2. 0	. 20	6. 6–7. 3	Low to moderate.
Pt					6. 3–20. 0	. 50	6. 6–7. 3	Variable.
Pt					6. 3–20. 0	. 50	7. 9–8. 0	Variable.
					[4]	[4]	[3]	Variable.
SM	A-2	95–100	95–100	15–30	6. 3–20. 0	. 12	6. 1–7. 3	Low.
SM or SC	A-2	95–100	90–100	25–35	0. 63–2. 0	. 10	5. 6–7. 8	Low.
SP–SM or SM	A-3 or A-2	55–80	50–70	5–20	6. 3–20. 0	. 04	[3] 7. 4–8. 0	Low.
ML–CL	A-4	100	100	55–80	0. 63–2. 0	. 20	6. 1–7. 3	Low.
CL or ML–CL	A-6 or A-4	100	100	70–90	0. 2–0. 63	. 16	6. 6–7. 8	Low to moderate.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Adrian: Ad, Ah. For Houghton part of Ah, see Houghton series.	Poor: erodible; readily oxidized. Fair to good if mixed with mineral material. High water table.	Fair; sandy material at a depth of 12 to 42 inches; excavation difficult because of high water table.	Not suitable.	Surface layers not suitable: organic material; unstable; highly compressible. Underlying material fair: sandy texture; excavation difficult because of high water table.	Not suitable: unstable organic material over rapidly permeable sand.
Algansee: Ak	Very poor: sandy texture; droughtiness; flood hazard; seasonal high water table.	Fair: considerable fines; stratified.	Not suitable.	Fair to good: low shrink-swell potential; fair to good bearing capacity.	Not suitable to fair: sandy texture; rapid permeability.
Allendale: AlA	Poor: sandy texture; droughtiness; low organic-matter content; seasonal high water table.	Fair: 18 to 40 inches of sandy material; some fines; excavation difficult when water table is high.	Not suitable.	Uppermost 18 to 40 inches fair: low shrink-swell potential; fair to good bearing capacity. Material at greater depths poor: high shrink-swell potential; poor workability; poor compaction characteristics.	Uppermost 18 to 40 inches not suitable: sandy texture; rapid permeability. Material at greater depths fair: poor workability; poor compaction characteristics.
Au Gres: AmB, AsB. For Saugatuck part of AsB, see Saugatuck series.	Very poor: sandy texture; droughtiness; low organic-matter content; seasonal high water table.	Good: poorly graded sandy material to a depth of 60 inches; excavation difficult when water table is high.	Not suitable.	Fair to good: low shrink-swell potential; seasonal high water table.	Not suitable: sandy texture; rapid permeability.
ArB	Very poor: sandy texture; droughtiness; low organic-matter content; seasonal high water table.	Fair: limited amount of poorly graded sandy material to a depth of 42 to 66 inches.	Not suitable.	Uppermost 42 to 66 inches fair to good: low shrink-swell potential. Material at greater depths poor to fair: loamy texture; moderate shrink-swell potential; fair workability.	Uppermost 42 to 66 inches not suitable: sandy texture; rapid permeability. Material at greater depths good: loamy texture; fair workability.
Belding: BeA, BeB	Fair: medium organic-matter content; seasonal high water table.	Not suitable.	Not suitable.	Uppermost 18 to 40 inches good: low shrink-swell potential. Material at greater depths poor to fair: moderate shrink-swell potential; poor bearing capacity.	Good: good workability to a depth of 18 to 40 inches; poor workability at greater depths when wet.
Blount: BlA, BlB	Fair: 8 to 10 inches thick; loamy texture; crusts slightly upon drying; seasonal high water table.	Not suitable.	Not suitable.	Poor to fair: moderate shrink-swell potential; fair workability; fair compaction characteristics.	Good: fair workability; fair compaction characteristics.

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Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
High water table; unstable organic material must be removed; sandy substratum.	High water table; 12 to 42 inches of unstable organic material; substratum has low shrink-swell potential and low compressibility and liquefies and flows when wet.	High water table; unstable organic material.	High	Low	Severe: high water table; unstable organic material; saturated in wet weather.
Seasonal high water table; flood hazard; fair to good bearing capacity.	Seasonal high water table; low shrink-swell potential; low compressibility; may liquefy and flow when wet.	High moisture content hinders operations at times.	Moderate	Low	Severe: seasonal high water table; flood hazard; possibility of contaminating shallow water supplies. Onsite investigation needed.
Seasonal high water table; plastic, clayey material at a depth of 18 to 40 inches; unstable and slippery when wet; seepage on side slopes; hazard of frost heave.	Seasonal high water table; high shrink-swell potential; high compressibility; low shear strength; hazard of frost heave.	High moisture content often hinders operations; poor stability upon thawing.	High	Low	Severe: seasonal high water table; slowly permeable material at a depth of 18 to 40 inches; seepage on slopes. Onsite investigation needed.
Seasonal high water table; sandy material liquefies and flows when wet.	Seasonal high water table; low shrink-swell potential; very low compressibility; fair to good shear strength; liquefies and flows when wet.	High moisture content often hinders operations.	Low	Moderate	Severe: seasonal high water table; rapid percolation; possibility of contaminating water supplies. Onsite investigation neeed.
Seasonal high water table; sandy material liquefies and flows when wet; hazard of frost heave in substratum.	Seasonal high water table; hazard of frost heave; moderate shrink-swell potential.	Seasonal high water table; poor stability upon thawing.	Moderate	Moderate	Severe: seasonal high water table; rapid percolation; possibility of contaminating water supplies. Onsite investigation needed.
Seasonal high water table; wetness hinders construction in some areas.	Seasonal high water table; hazard of frost heave; liquefies and flows when wet; moderate shrink-swell potential.	Moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Severe: seasonal high water table; moderately slowly permeable material at a depth of 18 to 40 inches. Onsite investigation needed.
Seasonal high water table hinders construction in some areas.	Seasonal high water table; moderate shrink-swell potential; medium compressibility; medium shear strength.	Moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Severe: seasonal high water table; moderately slowly permeable material within 24 inches of the surface Onsite investigation needed.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Blown-out land: BoB, BoF Onsite investigation needed.					
Bowers: BpA, BpB	Good: seasonal high water table; crusts slightly upon drying.	Not suitable	Not suitable	Poor to fair: moderate shrink-swell potential; poor to fair workability; poor to fair compaction characteristics.	Good: seasonal high water table; poor to fair workability; poor to fair compaction characteristics.
Boyer: BrA, BrB, BrC	Poor: droughtiness; low organic-matter content; gravel and cobblestones on the surface in many areas.	Good: sand with some fines and gravel.	Fair: more than 50 percent sand with some fines.	Good; low shrink-swell potential; sandy and gravelly material good for subgrade.	Uppermost 24 to 42 inches fair to good. Lower layers not suitable: sandy and gravelly texture; rapid permeability; piping hazard.
Breckenridge: Bu	Good: 6 to 8 inches thick; medium to high organic-matter content.	Not suitable	Not suitable	Uppermost 18 to 42 inches fair: low shrink-swell potential. Material at greater depths poor to fair: moderate shrink-swell potential; wetness hinders excavation.	Uppermost 18 to 42 inches fair: low shrink-swell potential; fair to good workability. Material at greater depths good: moderate shrink-swell potential; fair workability; high water table.
Brevort: Bv	Fair: 5 to 8 inches thick; droughtiness; medium to high organic-matter content.	Fair: limited amount to a depth of 18 to 40 inches.	Not suitable	Uppermost 18 to 40 inches fair to good: low shrink-swell potential. Material at greater depths poor to fair: loamy texture; moderate shrink-swell potential; fair workability.	Uppermost 18 to 40 inches not suitable: sandy texture; rapid permeability. Material at lower depths good: loamy texture; fair workability.
Bruce: By	Good: erodible; medium to high organic-matter content; high water table.	Not suitable	Not suitable	Poor: low to moderate shrink-swell potential; liquefies and flows when wet; high water table.	Fair: liquefies and flows when wet; high water table.
Carlisle: Cc	Poor: erodible; readily oxidized. Fair to good if mixed with mineral material. High water table.	Not suitable	Not suitable	Not suitable: organic material; unstable; very highly compressible.	Not suitable: organic material; unstable; very highly compressible.
Ceresco: Ce	Fair: sandy layers; flood hazard; seasonal high water table.	Not suitable	Not suitable	Fair to good: low shrink-swell potential.	Fair: possible seepage; piping hazard.
Chelsea: ChB, ChC, ClB.	Poor: 6 to 8 inches thick; sandy texture; droughtiness; low organic-matter content.	Good: sandy texture; thin layers of unsuitable material.	Not suitable	Fair to good: low shrink-swell potential.	Not suitable: sandy texture; rapid permeability; piping hazard.

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Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
Seasonal high water table hinders construction in some areas; hazard of frost heave.	Seasonal high water table; moderate shrink-swell potential; medium compressibility; medium shear strength.	Moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Severe: seasonal high water table; moderately slow permeability. Onsite investigation needed.
Cuts and fills needed in many places. Substratum a good source of fill and subbase material.	Low shrink-swell potential; very low compressibility; medium to high shear strength.	Moisture content usually low to medium; fair stability upon thawing.	Low to moderate.	Low	Slight: rapid drainage at a depth of 24 to 42 inches; some slopes of more than 10 percent; possibility of contaminating shallow water supplies.
High water table; wetness hinders construction.	High water table; moderate shrink-swell potential; medium compressibility; medium shear strength.	High water table; poor stability upon thawing.	High	Low	Severe: high water table; moderately slowly permeable material at a depth of 18 to 40 inches.
High water table; hazard of frost heave in substratum.	High water table; moderate shrink-swell potential; medium shear strength; medium compressibility.	High water table; moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Severe: moderately slowly permeable material at a depth of 18 to 40 inches; high water table.
High water table; substratum liquefies and flows when wet.	High water table; low shrink-swell potential; low compressibility; medium shear strength; liquefies and flows when wet.	High water table; poor stability upon thawing.	High	Low	Severe: high water table.
High water table; unstable organic material must be removed.	High water table; instability; very high compressibility.	High water table; unstable organic material.	High	Moderate	Severe: unstable organic material; high water table; saturated in wet weather.
Seasonal high water table; flood hazard.	Seasonal high water table; low shrink-swell potential; low compressibility; liquefies and flows when wet.	High moisture content hinders operations at times.	Moderate	Low	Severe: seasonal high water table; flood hazard. Onsite investigation needed.
Sandy texture; easy to excavate but has poor trafficability; hazard of soil blowing.	Low shrink-swell potential; very low compressibility.	Sandy texture; moisture content usually low; good stability upon thawing.	Low	Low	Slight: possibility of contaminating shallow water supplies; some slopes of more than 10 percent.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Cohoctah: Cm	Fair: slight droughtiness; medium organic-matter content; flood hazard; high water table.	Not suitable	Not suitable	Fair to good: low shrink-swell potential; high water table.	Fair: possible seepage; high water table; piping hazard.
Conover: CnB	Good: 10 to 14 inches thick; loamy texture; gravel and cobblestones on surface in places.	Not suitable	Not suitable	Poor to fair: low to moderate shrink-swell potential; fair workability; fair compaction characteristics.	Good: fair workability; fair compaction characteristics.
Croswell: CrB, CwB For Au Gres part of CwB, see Au Gres series.	Very poor: 6 to 10 inches thick; sandy texture; low organic-matter content; droughtiness.	Good: sandy texture to a depth of more than 60 inches.	Not suitable	Fair to good: low shrink-swell potential.	Not suitable: sandy texture; rapid permeability; piping hazard.
Deer Park: DpB, DpD, DpF.	Very poor: 6 to 8 inches thick; sandy texture; low organic-matter content; droughtiness.	Good: sandy texture to a depth of more than 60 inches.	Not suitable	Fair to good: low shrink-swell potential.	Not suitable: sandy texture; rapid permeability; piping hazard.
Edwards: Ed	Poor: erodible; readily oxidized. Fair to good if mixed with mineral material. High water table.	Not suitable	Not suitable	Not suitable: organic material over marl; unstable; highly compressible; high water table.	Not suitable: organic material over marl; unstable; highly compressible.
Fox: FoB	Fair: low organic-matter content; gravel and cobblestones on surface in places.	Good: stratified sand and gravel.	Good: stratified sand and gravel.	Uppermost 24 to 42 inches poor to fair: moderate shrink-swell potential; Material at greater depths good: sand and gravel; low shrink-swell potential; good for subgrade.	Uppermost 24 to 42 inches good: fair workability; fair compaction characteristics. Material at greater depths not suitable: sand and gravel; rapid permeability; piping hazard.
Gilford: Gd	Good: 10 to 14 inches thick; high organic-matter content.	Good: stratified sand and gravel; wetness hinders excavation in many areas.	Fair: less than 50 percent gravel; wetness hinders excavation in many areas.	Uppermost 18 to 40 inches fair: low shrink-swell potential. Material at greater depths good: sand and gravel; low shrink-swell potential; wetness hinders excavation in many areas.	Uppermost 18 to 40 inches fair: low shrink-swell potential. Material at greater depths not suitable: sand and gravel; rapid permeability; piping hazard.
Gladwin: GeA, GeB	Fair: 6 to 8 inches thick; medium organic-matter content; seasonal high water table.	Good: sand with some fines and some gravel.	Fair: less than 50 percent gravel.	Uppermost 18 to 40 inches fair: low shrink-swell potential. Material at greater depths good: sand and gravel; low shrink-swell potential; wetness hinders excavation.	Uppermost 18 to 40 inches fair: low shrink-swell potential. Material at greater depths not suitable: sand and gravel; rapid permeability; piping hazard.

roadbuilding and community development—Continued

Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
High water table; flood hazard.	High water table; low shrink-swell potential; low compressibility; medium to high shear strength; flood hazard.	High water table: wetness hinders operations; poor stability upon thawing.	Moderate	Low	Severe: high water table; flood hazard; saturated in wet weather.
Seasonal high water table; wetness hinders construction in some areas; hazard of frost heave.	Seasonal high water table; low to moderate shrink-swell potential; medium compressibility; medium shear strength.	Moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Severe: seasonal high water table; moderate permeability. Onsite investigation needed.
Sandy texture; easy to excavate but has poor trafficability; hazard of soil blowing.	Low shrink-swell potential; very low compressibility; liquefies and flows when wet.	Sandy texture; moisture content usually low; good stability upon thawing.	Low	Low	Slight to moderate: possibility of contaminating shallow water supplies; water table within 3 feet of surface in wet weather.
Cuts and fills needed in many places; sandy texture; easy to excavate but has poor trafficability; hazard of soil blowing.	Low shrink-swell potential; very low compressibility.	Sandy texture; moisture content usually low; good stability upon thawing.	Low	Low	Slight: possibility of contaminating shallow water supplies; slopes of more than 10 percent.
High water table; unstable organic material must be removed; unstable substratum.	High water table; 12 to 42 inches of unstable organic material over unstable marl; marl has poor shear strength.	High water table; 12 to 42 inches of unstable organic material.	High	Low	Severe: 12 to 42 inches of unstable organic material; high water table; saturated in wet weather.
Substratum a good source of fill and subbase material.	Low shrink-swell potential; very low compressibility; medium to high shear strength.	Moisture content usually too high for good compaction; poor stability upon thawing.	Low to moderate.	Low	Slight: rapid drainage at a depth of 24 to 42 inches; possibility of contaminating shallow water supplies.
High water table; wetness hinders construction.	High water table; low shrink-swell potential; very low compressibility; fair to good shear strength; liquefies and flows when wet.	High water table; wetness often hinders operations.	High	Low	Severe: high water table; saturated in wet weather; rapidly permeable sand and gravel at a depth of 18 to 40 inches.
Seasonal high water table; wetness hinders construction at times.	Seasonal high water table; low shrink-swell potential; very low compressibility; fair to good shear strength; liquefies and flows when wet.	High moisture content hinders operations at times.	Moderate	Low	Severe: seasonal high water table; very rapidly permeable sand and gravel at a depth of 18 to 40 inches; possibility of contaminating shallow water supplies. On-site investigation needed.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Glendora: Gl	Fair: sandy texture; medium organic-matter content; flood hazard; high water table.	Fair: some fines; wetness hinders excavation in many areas.	Not suitable	Fair to good: low shrink-swell potential; high water table.	Very poor: rapid permeability; liqeufies and flows when wet.
Granby: Gm, Gn	Good: sandy texture; high water table; medium to high organic-matter content; hazard of soil blowing.	Good: sandy texture; wetness hinders excavation in many areas.	Not suitable	Fair to good: low shrink-swell potential; high water table.	Not suitable: sandy texture; rapid permeability; high water table; piping hazard.
Gravel pits: Gr. Onsite investigation needed.					
Hettinger: Hg	Fair: 6 to 10 inches thick; loamy texture; high water table.	Not suitable	Not suitable	Poor to fair: moderate shrink-swell potential; high water table.	Good: poor to fair workability; poor to fair compaction characteristics.
Hillsdale: HlB, HlC	Poor: low organic-matter content; slight droughtiness.	Not suitable	Not suitable	Fair to good: low to moderate shrink-swell potential; good workability; good compaction characteristics.	Fair to good: good workability; good compaction characteristics.
Houghton. Mapped only in a complex with Adrian soils.	Poor: erodible; readily oxidized. Fair to good if mixed with mineral material. High water table.	Not suitable	Not suitable	Not suitable: unstable; very highly compressible.	Not suitable: unstable; very highly compressible.
Iosco: IoA, IrA, IsB. For Allendale part of IrA, see Allendale series. For Belding part of IsB, see Belding series.	Poor: 7 to 9 inches thick; low organic-matter content; droughtiness.	Fair: limited amount of sandy material to a depth of 18 to 40 inches.	Not suitable	Uppermost 18 to 40 inches fair to good: low shrink-swell potential. Material at greater depths poor to fair: loamy texture; moderate shrink-swell potential; fair workability; fair compaction characteristics.	Uppermost 18 to 40 inches not suitable: sandy texture; rapid permeability. Material at greater depths good: loamy texture; fair workability; fair compaction characteristics.
Kalkaska: KaC	Very poor: 3 to 8 inches thick; sandy texture; low organic-matter content; droughtiness.	Good: sandy texture to a depth of more than 60 inches.	Not suitable	Fair to good: low shrink-swell potential.	Not suitable: sandy texture; rapid permeability; piping hazard.
Kawkawlin: KnA, KnB.	Fair: 6 to 10 inches thick; loamy texture; slight crusting upon drying; seasonal high water table.	Not suitable	Not suitable	Poor to fair: moderate shrink-swell potential; fair workability; fair compaction characteristics.	Good: fair workability; fair compaction characteristics.

roadbuilding and community development—Continued

Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
High water table; flood hazard.	High water table; low shrink-swell potential; low compressibility; medium to high shear strength; flood hazard.	High water table; wetness hinders operations.	Moderate	Low	Severe: high water table; flood hazard.
High water table; loses stability and flows when wet.	High water table; low shrink-swell potential; very low compressibility; high shear strength; liquefies and flows when wet.	High water table; wetness hinders operations.	High	Low	Severe: high water table; rapid permeability; saturated in wet weather.
High water table; wetness hinders construction.	High water table; moderate shrink-swell potential; medium compressibility; medium shear strength.	High water table; poor stability upon thawing.	High	Low	Severe: high water table; moderately slowly permeable material within 24 inches of the surface; saturated in wet weather.
Cuts and fills needed in many places; stones hinder grading in some areas.	Low shrink-swell potential; low compressibility.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Slight: moderate permeability; some slopes of more than 10 percent.
High water table; unstable organic material must be removed.	High water table; very high compressibility; instability.	High water table; unstable organic material.	High	Moderate	Severe: high water table; unstable organic material; saturated in wet weather.
Seasonal high water table; hazard of frost heave in substratum.	Seasonal high water table; moderate shrink-swell potential; medium shear strength; medium compressibility.	Seasonal high water table; moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Severe: moderately slowly permeable material below a depth of 18 to 40 inches; seasonal high water table.
Cuts and fills needed in many places; sandy texture; easy to excavate but has poor trafficability; hazard of soil blowing.	Low shrink-swell potential; very low compressibility, liquefies and flows when wet.	Sandy texture; moisture content usually low; good stability upon thawing.	Low	Low to moderate.	Slight: possibility of contaminating shallow water supplies; some slopes of more than 10 percent.
Seasonal high water table hinders construction in some areas; hazard of frost heave.	Seasonal high water table; moderate shrink-swell potential; medium compressibility; medium shear strength.	Moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Severe: seasonal high water table; moderately slowly permeable material within 24 inches of the surface. Onsite investigation needed.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Kibbie: KoA, KoB	Good: 8 to 12 inches thick; loamy texture; medium organic-matter content; seasonal high water table.	Not suitable	Not suitable	Poor: low shrink-swell potential; liquefies and flows when wet.	Fair: liquefies and flows when wet.
Lacota: La	Good: 7 to 14 inches thick; loamy texture; medium to high organic-matter content; high water table.	Good below depth of 18 to 40 inches: sandy texture; wetness hinders excavation.	Not suitable	Uppermost 18 to 40 inches poor to fair: moderate shrink-swell potential. Material at greater depths good: sandy texture; low shrink-swell potential; good for subgrade; high water table.	Uppermost 18 to 40 inches good: fair workability; fair compaction characteristics. Material at greater depths not suitable: sandy texture; rapid permeability; piping hazard.
Lake beaches: Lb. Onsite investigation needed.					
Linwood: Ls	Poor: erodible; readily oxidized. Fair to good if mixed with mineral material. High water table.	Not suitable	Not suitable	Uppermost 12 to 42 inches not suitable; organic material; unstable; highly compressible. Material at greater depths poor to fair: loamy texture; low shrink-swell potential; high water table.	Uppermost 12 to 42 inches not suitable; organic material; unstable; highly compressible. Material at greater depths good: loamy texture; fair workability; high water table.
Made land: Ma. Onsite investigation needed.					
Mancelona: McA, McB, McC.	Poor: droughtiness; low organic-matter content; gravel and cobblestones on surface in many areas.	Good: sand with some fines and some gravel.	Fair: more than 50 percent sand with some fines.	Good: low to moderate shrink-swell potential; sand and gravel good for subgrade.	Uppermost 18 to 40 inches fair to good. Material at greater depths not suitable: sandy and gravelly texture; very rapid permeability; hazard of piping.
Marsh: Me. Onsite investigation needed.					
Matherton: MhA	Good: medium content of organic matter; seasonal high water table; gravel and cobblestones on surface in some areas.	Good: stratified sand and gravel; wetness hinders excavation.	Good: stratified sand and gravel; wetness hinders excavation.	Uppermost 24 to 40 inches poor to fair: moderate shrink-swell potential. Material at greater depths good: sandy and gravelly texture; low shrink-swell potential; good for subgrade.	Uppermost 24 to 40 inches good: fair workability; fair compaction characteristics. Material at greater depths not suitable: sandy and gravelly texture; very rapid permeability; piping hazard.

roadbuilding and community development—Continued

Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
Seasonal high water table; substratum liquefies and flows when wet; hazard of frost heave.	Seasonal high water table; low shrink-swell potential; liquefies and flows when wet.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Severe: seasonal high water table; when wet, soil material may flow into and plug tile lines and filter beds. Onsite investigation needed.
High water table; wetness hinders construction.	High water table; low shrink-swell potential; very low compressibility; good shear strength.	High water table; wetness often hinders operations.	High	Low	Severe: high water table; rapidly permeable material at a depth of 18 to 40 inches; saturated in wet weather.
High water table; unstable organic material must be removed.	High water table; 12 to 42 inches of unstable organic material; fair shear strength in substratum.	High water table; unstable organic material.	High	Low	Severe: high water table; unstable organic material; saturated in wet weather.
Cuts and fills needed in many places; substratum a good source of material for subbase and fill.	Low shrink-swell potential; very low compressibility; medium to high shear strength.	Moisture content usually low to medium; fair stability upon thawing.	Low to moderate.	Low	Slight: rapid drainage at a depth of 18 to 40 inches; possibility of contaminating shallow water supplies; some slopes of more than 10 percent.
Seasonal high water table; wetness may hinder construction.	Seasonal high water table; low shrink-swell potential; low compressibility; high shear strength.	Moisture content high enough at times to hinder operations.	Moderate	Low	Severe: seasonal high water table; possibility of contaminating shallow water supplies. Onsite investigation needed.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Menominee: MmB, MmC.	Very poor: 5 to 9 inches thick; low organic-matter content; droughtiness.	Fair: limited amount of sandy material to a depth of 18 to 40 inches.	Not suitable.	Uppermost 18 to 40 inches fair to good: low shrink-swell potential. Material at greater depths poor to fair: loamy texture; moderate shrink-swell potential; fair workability; fair compaction characteristics.	Uppermost 18 to 40 inches not suitable: sandy texture; rapid permeability. Material at greater depths good: loamy texture; fair workability; fair compaction characteristics.
Metamora: MnA, MnB.	Fair: 6 to 10 inches thick; medium organic-matter content; seasonal high water table.	Not suitable.	Not suitable.	Upermost 24 to 40 inches good: low shrink-swell potential. Material at greater depths poor to fair: moderate shrink-swell potential.	Good: workability good in uppermost 24 to 40 inches and poor at greater depths.
Miami: MoB, MoC, MoD, MoF.	Fair: 6 to 10 inches thick; gravel and cobblestones on the surface in places.	Not suitable.	Not suitable.	Poor to fair: low to moderate shrink-swell potential; fair workability; fair compaction characteristics.	Good: fair workability; fair compaction characteristics.
Montcalm: MrA, MrB, MrC.	Very poor: 4 to 8 inches thick; sandy texture; low organic-matter content; droughtiness.	Good: sandy texture; thin layers of unsuitable material.	Not suitable.	Fair to good: low shrink-swell potential.	Not suitable: sandy texture; rapid permeability; piping hazard.
Morley: MtB, MtC2, MtE2, MuD3, MuF3.	Fair: 6 to 9 inches thick; loamy texture; low organic-matter content; droughtiness.	Not suitable.	Not suitable.	Poor to fair: moderate to high shrink-swell potential; poor to fair workability; poor to fair compaction characteristics.	Good: poor to fair workability; poor to fair compaction characteristics.
Nester: NeB, NeC, NeD, NeE, NeF, NsC3 NsD3, NsE3, NsF3.	Uneroded soils fair: 7 to 9 inches thick; loamy texture; low organic-matter content; a few pebbles and cobblestones on the surface.	Not suitable.	Not suitable.	Poor to fair: moderate to high shrink-swell potential; poor to fair workability; poor to fair compaction characteristics.	Good: poor to fair workability; poor to fair compaction characteristics.
Newaygo: NwB.	Fair: low organic-matter content; droughtiness; gravel and cobblestones on surface in some areas.	Good: sand with some fines and some gravel.	Good: more than 40 percent gravel.	Good: low to moderate shrink-swell potential; sandy and gravelly material good for subgrade and subbase.	Uppermost 24 to 40 inches fair to good. Material at greater depths not suitable: sandy and gravelly texture; rapid permeability; piping hazard.
Oshtemo: OsA, OsB, OsC, OsD.	Poor: low organic-matter content; droughtiness; gravel and cobblestones on the surface in many areas.	Good: stratified sand and gravel.	Fair: dominantly sandy material.	Good: low to moderate shrink-swell potential; sandy and gravelly material good for subgrade and subbase.	Uppermost 40 to 66 inches fair to good. Material at greater depths not suitable: sandy and gravelly texture; rapid permeability; piping hazard.

roadbuilding and community development—Continued

Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
Cuts and fills needed in many places.	Moderate shrink-swell potential; medium shear strength; medium compressibility.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Severe: moderately slowly permeable material at a depth of 18 to 40 inches; some slopes of more than 10 percent.
Seasonal high water table; wetness hinders construction in some areas.	Seasonal high water table; moderate shrink-swell potential; hazard of frost heave.	Moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Severe: seasonal high water table; moderately slowly permeable material at a depth of 24 to 40 inches. Onsite investigation needed.
Cuts and fills needed in many places; hazard of frost heave.	Low to moderate shrink-swell potential; medium shear strength; hazard of frost heave.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Moderate: moderate permeability; some slopes of more than 10 percent.
Sandy texture; easy to excavate but has poor trafficability; hazard of soil blowing.	Low shrink-swell potential; very low compressibility.	Sandy texture; moisture content usually low; good stability upon thawing.	Low	Low	Slight: possibility of contaminating shallow water supplies; some slopes of more than 10 percent.
Cuts and fills needed in many places; hazard of frost heave.	Moderate shrink-swell potential; medium shear strength; medium compressibility.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Severe: moderately slow permeability; some slopes of more than 10 percent. Onsite investigation needed.
Cuts and fills needed in many places; hazard of frost heave.	Moderate shrink-swell potential; medium shear strength; medium compressibility.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Severe: moderately slow permeability; some slopes of more than 10 percent. Onsite investigation needed.
Substratum a good source of fill and subbase material.	Low shrink-swell potential; very low compressibility; medium to high shear strength.	Mositure content usually low to medium; fair stability upon thawing.	Low to moderate.	Low	Slight: rapid drainage at a depth of 24 to 40 inches; possibility of contaminating shallow water supplies.
Cuts and fills needed in many places; substratum a good source of fill and subbase material.	Low shrink-swell potential; very low compressibility; medium to high shear strength.	Moisture content usually low to medium; fair stability upon thawing.	Low to moderate.	Low	Slight: rapidly permeable material at a depth of 40 to 66 inches; possibility of contaminating shallow water supplies; some slopes of more than 10 percent.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Owosso: OwB	Fair: 7 to 10 inches thick; low to medium organic-matter content.	Not suitable	Not suitable	Uppermost 18 to 40 inches good: low shrink-swell potential. Material at greater depths fair: moderate to low shrink-swell potential.	Good: workability and compaction characteristics good in uppermost 18 to 40 inches and fair at greater depths.
Pinconning: Pn, Pr. For Breckenridge part of Pr, see Breckenridge series.	Poor: sandy texture; droughtiness; medium organic-matter content; high water table.	Fair: 18 to 40 inches of sandy material with some fines; high water table hinders excavation in wet weather.	Not suitable	Uppermost 18 to 40 inches fair to good: low shrink-swell potential. Material at greater depths poor: high shrink-swell potential; poor workability; poor compaction characteristics.	Uppermost 18 to 40 inches not suitable: sandy texture; rapid permeability. Material at greater depths fair: poor workability; poor compaction characteristics.
Richter: RcA, RcB	Fair: thin; loamy texture; low organic-matter content.	Not suitable	Not suitable	Fair to good: low shrink-swell potential.	Fair: good workability; good compaction characteristics; liquefies and flows when wet.
Rubicon: RsB, RsD, RsF.	Very poor: 3 to 6 inches thick; sandy texture; low organic-matter content; droughtiness.	Good: sandy texture to a depth of more than 60 inches.	Not suitable	Fair to good: low shrink-swell potential.	Not suitable: sandy texture; rapid permeability; piping hazard.
Sand pits: Sd. Onsite investigation needed.					
Saugatuck. Mapped only in a complex with Au Gres soils.	Very poor: sandy texture; low organic-matter content; droughtiness; seasonal high water table.	Good: sandy texture to a depth of more than 60 inches; high water table and cemented layer hinder excavation.	Not suitable	Fair to good: low shrink-swell potential.	Not suitable: sandy texture; rapid permeability.
Selkirk: SeA, SeB	Fair: 8 to 10 inches thick; low organic-matter content; crusts upon drying; seasonal high water table.	Not suitable	Not suitable	Poor: low shear strength; poor workability; poor to fair compaction characteristics; high shrink-swell potential; seasonal high water table.	Fair: high shrink-swell potential; poor workability; poor to fair compaction characteristics; seasonal high water table.
Shoals: Sh	Good: 6 to 14 inches thick; loamy texture; low to medium organic-matter content; flood hazard; seasonal high water table.	Not suitable	Not suitable	Poor: low to moderate shrink-swell potential; fair workability; fair compaction characteristics; poor subgrade material.	Fair to good: fair workability; fair compaction characteristics.

roadbuilding and community development—Continued

Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
Hazard of frost heave below a depth of 18 to 40 inches.	Moderate shrink-swell potential; hazard of frost heave.	Moisture content often too high for good compaction; poor stability upon thawing.	High	Low	Moderate: moderately permeable material at a depth of 18 to 40 inches. Onsite investigation needed.
High water table; at a depth of 18 to 40 inches is plastic, clayey material that is unstable and slippery when wet.	High water table; high shrink-swell potential; high compressibility; low shear strength.	Moisture content often high enough to hinder operations; poor stability upon thawing.	High	Low	Severe: high water table; slowly permeable material at a depth of 18 to 40 inches. Onsite investigation needed.
Seasonal high water table; wetness hinders construction in some areas; hazard of frost heave.	Seasonal high water table: low shrink-swell potential; low compressibility; medium shear strength; liquefies and flows when wet.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Severe: seasonal high water table; moderate permeability. Onsite investigation needed.
Cuts and fills needed in many places; easy to excavate but has poor trafficability; hazard of soil blowing.	Low shrink-swell potential; very low compressibility.	Sandy texture; moisture content usually low; good stability upon thawing.	Low	Low	Slight: possibility of contaminating shallow water supplies; slopes of more than 10 percent.
Seasonal high water table; liquefies and flows when wet; fill needed.	Seasonal high water table; low shrink-swell potential; very low compressibility; fair to good shear strength; liquefies and flows when wet.	Moisture content often high enough to hinder operations.	Low	Moderate to high.	Severe: seasonal high water table; generally rapid permeability; possibility of contaminating water supplies; slowly permeable cemented layer. Onsite investigation needed.
Seasonal high water table; plastic, clayey material that is unstable and slippery when wet; poor bearing capacity.	Seasonal high water table; high shrink-swell potential; high compressibility; low shear strength; hard when dry.	Moisture content often high enough to hinder operations; poor stability upon thawing.	High	Low	Severe: seasonal high water table; slow permeability; saturated in wet weather. Onsite investigation needed.
Seasonal high water table; flood hazard; hazard of frost heave.	Seasonal high water table; low shrink-swell potential; medium compressibility; medium shear strength; flood hazard.	Moisture content often high enough to hinder operations; poor stability upon thawing.	High	Low	Severe: flood hazard; moderately slow permeability. Onsite investigation needed.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Sims: Sm	Good: 8 to 12 inches thick; loamy texture; medium to high organic-matter content; high water table.	Not suitable	Not suitable	Poor to fair: high to moderate shrink-swell potential; poor to fair workability; poor to fair compaction characteristics; high water table.	Good: poor to fair workability; poor to fair compaction characteristics; high water table.
Sloan: Sn	Good: thick; loamy texture; medium organic-matter content; flood hazard; seasonal high water table.	Not suitable	Not suitable	Poor: moderate to low shrink-swell potential; high water table; fair workability; fair compaction characteristics; poor subgrade material.	Fair to good: fair workability; fair compaction characteristics; high water table.
Spinks: SpA, SpB, SpC, SsD, SsE, SsF. For Montcalm part of SsD, SsE, and SsF, see Montcalm series.	Very poor: 6 to 8 inches thick; sandy texture; low organic-matter content; droughtiness.	Good: sandy texture; thin layers of unsuitable material.	Not suitable	Fair to good: low shrink-swell potential.	Not suitable: sandy texture; rapid permeability; piping hazard.
Toledo: Tc	Fair: 6 to 10 inches thick; medium to high organic-matter content; high water table.	Not suitable	Not suitable	Poor: high shrink-swell potential; poor to fair workability; poor to fair compaction characteristics; high water table.	Good: high shrink-swell potential; poor to fair workability; poor to fair compaction characteristics; high water table.
Tonkey: To	Good: erodible; medium to high organic-matter content; high water table.	Not suitable	Not suitable	Poor: low shrink-swell potential; liquefies and flows when wet; high water table.	Fair: liquefies and flows when wet; high water table.
Tuscola: TsB	Fair: 8 to 11 inches thick; loamy texture; low organic-matter content.	Not suitable	Not suitable	Poor: moderate to low shrink-swell potential; liquefies and flows when wet.	Fair: liquefies and flows when wet.
Ubly: UlA, UlB, UlC	Fair: 8 to 10 inches thick; low organic-matter content.	Not suitable	Not suitable	Uppermost 18 to 40 inches good: low shrink-swell potential. Material at greater depths fair: moderate shrink-swell potential.	Good: workability and compaction characteristics good in uppermost 18 to 40 inches and fair at greater depths.
Wallkill: Wa	Good: loamy texture; medium organic-matter content; flood hazard; high water table.	Not suitable	Not suitable	Uppermost 10 to 40 inches poor: moderate to low shrink-swell potential. Material at greater depths not suitable; organic layers that are unstable and very highly compressible; high water table.	Uppermost 10 to 40 inches fair to good. Material at greater depths not suitable: organic layers that are unstable and very highly compressible; high water table.

roadbuilding and community development—Continued

Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
High water table; wetness hinders construction; hazard of frost heave.	High water table; moderate shrink-swell potential; medium compressibility; medium shear strength.	High water table; poor stability upon thawing.	High	Low	Severe: high water table; moderately slowly permeable material within 24 inches of the surface; saturated in wet weather.
High water table; flood hazard; hazard of frost heave.	High water table; low shrink-swell potential; medium compressibility; medium shear strength.	High water table; wetness hinders operations; poor stability upon thawing.	High	Low	Severe: high water table; flood hazard; moderately slow permeability.
Cuts and fills needed in many places; easy to excavate but has poor trafficability; hazard of soil blowing.	Low shrink-swell potential; very low compressibility.	Sandy texture; moisture content usually low; good stability upon thawing.	Low	Low	Slight: possibility of contaminating shallow water supplies; some slopes of more than 10 percent.
High water table; plastic, clayey material that is unstable and slippery when wet; low shear strength.	High water table; high shrink-swell potential; high compressibility; low shear strength; hard when dry.	High water table; clayey texture; poor stability upon thawing.	High	Low	Severe: high water table; slowly permeable material within 24 inches of the surface; saturated in wet weather.
High water table; substratum liquefies and flows when wet; hazard of frost heave.	High water table; liquefies and flows when wet; low shrink-swell potential; low compressibility; fair shear strength.	High water table; poor stability upon thawing.	High	Low	Severe: high water table; saturated in wet weather.
Substratum unstable; liquefies and flows when wet; hazard of frost heave.	Low shrink-swell potential; liquefies and flows when wet; hazard of frost heave and reduction of bearing capacity upon thawing.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Moderate: liquefies readily and may flow into and plug tile lines and filter beds.
Cuts and fills needed in many areas; hazard of frost heave below a depth of 18 to 40 inches.	Moderate shrink-swell potential; hazard of frost heave.	Moisture content often too high for good compaction; poor stability upon thawing.	Moderate	Low	Moderate: moderately slowly permeable material at a depth of 18 to 40 inches. Onsite investigation needed.
High water table; unstable organic material must be removed; flood hazard.	High water table; very high compressibility; unstable organic material below a depth of 10 to 40 inches.	Unstable organic material at a depth of 10 to 40 inches; high water table; wetness hinders operations.	High	Low	Severe: high water table; flood hazard; unstable organic material at a depth of 10 to 40 inches.

TABLE 5.—*Engineering interpretations for*

Soil series and map symbols	Suitability as source of—				
	Topsoil	Sand	Gravel	Road fill for highway subgrade	Impermeable material
Warners: Wm	Poor: erodible; readily oxidized. Fair to good if mixed with mineral material. High water table.	Not suitable	Not suitable	Not suitable: organic material over marl; unstable; highly compressible.	Not suitable: organic material over marl; unstable; highly compressible.
Wasepi: WsA	Fair: 6 to 10 inches thick; medium organic-matter content; seasonal high water table.	Good: sandy; some fines and some gravel.	Fair: less than 50 percent gravel.	Uppermost 24 to 40 inches fair: low shrink-swell potential. Material at greater depths good: sandy and gravelly texture; seasonal high water table; wetness hinders excavation.	Uppermost 24 to 40 inches fair: low shrink-swell potential. Material at greater depths not suitable: sandy and gravelly texture; rapid permeability; piping hazard.
Washtenaw: Wt	Good: thick; loamy texture; medium organic-matter content; flood hazard; high water table.	Not suitable	Not suitable	Poor: moderate to low shrink-swell potential; poor to fair workability; poor to fair compaction characteristics; high water table.	Good: poor to fair workability; poor to fair compaction characteristics; high water table.
Wind eroded land, sloping: WuC. Onsite investigation needed.					

roadbuilding and community development—Continued

Soil properties affecting—			Corrosivity		Limitations for use as sewage-disposal field
Highway location	Foundations for low buildings	Winter grading	Uncoated steel	Concrete	
High water table; unstable organic material must be removed.	High water table; less than 12 inches of unstable organic material over marl; marl has poor shear strength.	High water table; unstable organic material over marl.	High	Low	Severe: high water table; unstable organic material over marl; saturated in wet weather.
Seasonal high water table; wetness hinders construction at times.	Seasonal high water table; low shrink-swell potential; very low compressibility; fair to good shear strength; liquefies and flows when wet.	Moisture content high enough at times to hinder operations.	Moderate	Low	Severe: seasonal high water table; rapidly permeable material at a depth of 24 to 40 inches; possiblity of contaminating shallow water supplies. Onsite investigation needed.
High water table; flood hazard; hazard of frost heave.	High water table; moderate to low shrink-swell potential; medium compressibility; medium shear strength.	High water table; wetness hinders operations; poor stability upon thawing.	High	Low	Severe: high water table; flood hazard; slow permeability; saturated in wet weather.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil properties affecting—	
	Farm ponds	
	Reservoir area	Embankment
Adrian: Ad, Ah For Houghton part of Ah, see Houghton series.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.	High water table; 12 to 42 inches of unstable organic material; sandy substratum is rapidly permeable and subject to piping.
Algansee: Ak	Flood hazard; rapid seepage	Seasonal high water table; fair stability; fair to good compaction characteristics; medium rate of seepage; piping hazard.
Allendale: AlA	Rapid seepage in loamy and sandy upper layers; slow seepage in clayey substratum.	Seasonal high water table; uppermost 18 to 40 inches has rapid seepage and is subject to piping; clayey substratum has high shrink-swell potential, poor compaction characteristics, and slow seepage and is unstable when wet.
Au Gres: AmB, AsB For Saugatuck part of AsB, see Saugatuck series.	Too porous to hold water; seal blanket necessary.	Seasonal high water table; fair stability; fair compaction characteristics; rapid seepage; hazard of piping.
ArB	Seasonal high water table; rapid seepage to a depth of 42 to 66 inches; medium to slow seepage at greater depths; seal blanket necessary unless sandy upper layers are removed.	Seasonal high water table; fair stability; fair compaction characteristics; slow seepage below a depth of 42 to 66 inches.
Belding: BeA, BeB	Medium to slow seepage	Fair to good stability; fair to good compaction characteristics; slow seepage.
Blount: BlA, BlB	Medium to slow seepage	Fair to good stability; slow seepage; fair compaction characteristics.
Blown-out land: BoB, BoF. Onsite investigation needed.		
Bowers: BpA, BpB	Medium to slow seepage	Fair stability; poor to fair compaction characteristics; slow seepage.
Boyer: BrA, BrB, BrC	Medium to rapid seepage in subsoil; seal blanket needed if sand and gravel are exposed.	Uppermost 24 to 42 inches has fair stability, a medium rate of seepage, and fair to good compaction characteristics. Substratum has good stability and rapid seepage and is subject to piping.
Breckenridge: Bu	High water table; medium rate of seepage; suitable for pit-type ponds.	High water table; fair to good stability; fair to good compaction characteristics; slow seepage.
Brevort: Bv	High water table; rapid seepage to a depth of 18 to 40 inches; slow to medium seepage at greater depths; seal blanket needed unless sandy material is removed.	High water table; fair stability; fair compaction characteristics; slow to medium seepage below a depth of 18 to 40 inches.
Bruce: By	High water table; medium rate of seepage; suitable for pit-type ponds; sides of ponds unstable when wet.	High water table. Subsoil has fair stability and slow seepage. Substratum has poor stability and a medium rate of seepage and is subject to piping.

interpretations for farm uses

Soil properties affecting—Continued			
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
High water table; sandy substratum makes feasibility of tiling questionable; ditchbanks unstable.	Moderate available water capacity; rapid water intake; poor natural drainage.	Not needed: nearly level or depressional; slow runoff.	Not needed: nearly level or depressional.
Normally not suitable for crops because of flood hazard and sandy texture.	Low available water capacity; very rapid water intake; flood hazard.	Not needed: nearly level.	Generally not needed: nearly level.
Seasonal high water table; slowly permeable clayey material below a depth of 18 to 40 inches; somewhat poor natural drainage.	Moderate available water capacity; very rapid water intake; slowly permeable clayey material below a depth of 18 to 40 inches; seepage may develop on slopes.	Generally not needed: short, irregular slopes; very rapid water intake; little runoff.	Generally not needed: nearly level to gently sloping.
Sandy texture; rapid permeability; wet depressions; ditchbanks unstable; feasibility of tiling quesionable; risk of overdrainage.	Low available water capacity; very rapid water intake.	Not needed: very rapid intake; little runoff.	Sandy texture; short, gentle slopes; low available water capacity; low fertility.
Sandy upper layers; rapid permeability to a depth of 42 to 66 inches; moderately slow permeability at greater depths; wet depressions; ditchbanks unstable; risk of overdrainage.	Low available water capacity; very rapid water intake.	Not needed: sandy texture; little runoff.	Sandy texture; short, gentle slopes; low available water capacity; low fertility.
Moderately slow permeability below a depth of 18 to 40 inches; seasonal high water table; wet depressions.	Moderate available water capacity; rapid water intake.	Generally not needed: slopes short and in many places irregular.	Seepage; wetness may delay construction.
Moderately slow permeability; seasonal high water table; wet depressions.	High available water capacity; medium rate of water intake.	Generally not needed; slopes short and in many places irregular.	Seasonal high water table.
Moderately slow permeability; seasonal high water table; wet depressions.	High available water capacity; medium rate of water intake.	Not needed: nearly level to gently sloping.	Seasonal high water table.
Not needed	Low available water capacity; very rapid water intake; runoff and erosion hazard in sloping areas.	Erosion hazard; slow to medium runoff. Avoid cuts into gravelly layers.	Sandy texture; droughtiness; erosion hazard; slow to medium runoff; difficult to establish vegetation.
Moderately slow permeability below a depth of 18 to 40 inches; high water table; wet depressions.	Moderate available water capacity; rapid water intake; poor natural drainage.	Not needed: nearly level; slow runoff.	Not needed but may be used to remove surface water.
High water table; moderately slow permeability below a depth of 18 to 40 inches; wet depressions.	Moderate available water capacity; very rapid water intake; high water table; poor natural drainage.	Not needed: nearly level; slow runoff.	Not needed: nearly level; high water table; may be used to remove surface water.
High water table; substratum loses stability when wet and may flow into and plug tile lines; ditchbanks unstable.	High available water capacity; medium rate of water intake; poor natural drainage.	Not needed: nearly level; slow runoff.	Not needed: nearly level; high water table.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil properties affecting—	
	Farm ponds	
	Reservoir area	Embankment
Carlisle: Cc	High water table; rapid seepage; suitable for pit-type ponds; flotation and caving in of organic material likely.	Unstable organic material; high water table.
Ceresco: Ce	Flood hazard; rapid seepage	Seasonal high water table; fair stability; fair to good compaction characteristics; medium rate of seepage; piping hazard.
Chelsea: ChB, ChC, ClB	Rapid seepage; too porous to hold water unless a seal blanket is used.	Medium to rapid seepage; fair stability; fair compaction characteristics; piping hazard; low shrink-swell potential.
Cohoctah: Cm	High water table; rapid seepage; flood hazard; suitable for pit-type ponds.	High water table; fair stability; fair to good compaction characteristics; medium rate of seepage; piping hazard.
Conover: CnB	Medium to slow seepage	Fair to good stability; fair compaction characteristics; slow seepage.
Croswell: CrB, CwB For Au Gres part of CwB, see Au Gres series.	Rapid seepage; too porous to hold water unless a seal blanket is used.	Rapid seepage; fair stability; fair compaction characteristics; piping hazard; low shrink-swell potential.
Deer Park: DpB, DpD, DpF	Rapid seepage; too porous to hold water unless a seal blanket is used.	Rapid seepage; fair stability; fair compaction characteristics; piping hazard; low shrink-swell potential.
Edwards: Ed	High water table; rapid seepage to a depth of 12 to 42 inches; slow seepage at greater depths; suitable for pit-type ponds; flotation of organic material possible.	High water table; 12 to 42 inches of unstable organic material over marl; marl has poor stability and poor compaction characteristics.
Fox: FoB	Medium to slow seepage to a depth of 24 to 42 inches; seal blanket needed if sand and gravel are exposed.	Uppermost 24 to 42 inches has fair stability, slow seepage, and fair compaction characteristics. Substratum has good stability and rapid seepage.
Gilford: Gd	High water table; rapid seepage in substratum; suitable for pit-type ponds.	High water table. Uppermost 18 to 40 inches has fair to good stability and slow seepage. Substratum has fair stability and rapid seepage and is subject to piping.
Gladwin, GeA, GeB	Medium rate of seepage to a depth of 18 to 40 inches; seal blanket needed if sand and gravel are exposed.	Uppermost 18 to 40 inches has fair stability, a medium seepage rate, and fair to good compaction characteristics. Substratum has fair stability, fair compaction characteristics, and rapid seepage.
Glendora: Gl	High water table; rapid seepage; flood hazard; suitable for pit-type ponds.	High water table; fair stability; fair to good compaction characteristics; medium rate of seepage; piping hazard.
Granby: Gm, Gn	High water table; rapid seepage; suitable for pit-type ponds.	High water table; fair stability; fair compaction characteristics; rapid seepage; piping hazard.

interpretations for farm uses—Continued

Soil properties affecting—Continued			
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
High water table; organic material may settle if overdrained.	High available water capacity; very rapid water intake; very poor natural drainage.	Not needed: nearly level to depressional.	Not needed: nearly level to depressional.
Seasonal high water table; flood hazard.	Moderate available water capacity; rapid water intake; flood hazard.	Not needed: nearly level.	Not needed: nearly level.
Not needed	Low available water capacity; rapid water intake; hazard of soil blowing.	Generally not needed; sandy texture; little runoff.	Droughtiness; low fertility; sandy texture; difficult to construct waterways and to establish vegetation.
High water table; flood hazard	High available water capacity; medium rate of water intake; very poor natural drainage; flood hazard.	Not needed: level to depressional.	Not needed: level to depressional.
Moderate permeability; seasonal high water table; wet depressions.	High available water capacity; medium rate of water intake.	Generally not needed: slopes are short, gentle, and in many places irregular.	Seasonal high water table.
Not needed	Low available water capacity; very rapid water intake; hazard of soil blowing.	Not needed: sandy texture; little runoff.	Sandy texture; low available water capacity; low fertility; little runoff.
Not needed	Very low available water capacity; very rapid water intake; hazard of soil blowing.	Not needed: sandy texture; little runoff.	Sandy texture; very low available water capacity; very low fertility; erosion hazard; steep slopes; construction difficult.
High water table; organic material may settle if overdrained.	Very high available water capacity; very rapid water intake; very poor natural drainage.	Not needed: nearly level; slow runoff.	Not needed: nearly level.
Not needed	Moderate available water capacity; rapid water intake; runoff and erosion hazard in sloping areas.	Short slopes. Avoid cuts into gravelly substratum.	No unfavorable properties.
High water table; moderate permeability to a depth of 18 to 40 inches; rapid permeability at greater depths; sandy substratum makes blinding necessary.	Low available water capacity; rapid water intake; poor to very poor natural drainage.	Not needed: nearly level; slow runoff.	Not needed: nearly level.
Seasonal high water table; sand and gravel substratum makes blinding necessary.	Low available water capacity; rapid water intake; sand and gravel at a depth of 18 to 40 inches.	Not needed: short slopes; little runoff.	Short slopes; little runoff; low available water capacity.
Normally not suitable for crops; flood hazard; sandy substratum.	Low available water capacity; very rapid water intake; flood hazard; poor to very poor natural drainage.	Not needed: nearly level to depressional.	Not needed: nearly level to depressional.
High water table; wet depressions; ditchbanks unstable; very sandy substratum makes feasibility of tiling questionable.	Low available water capacity; rapid water intake; poor to very poor natural drainage.	Not needed; nearly level; little runoff.	Not needed: nearly level.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil properties affecting—	
	Farm ponds	
	Reservoir area	Embankment
Gravel pits: Gr. Onsite investigation needed.		
Hettinger: Hg	High water table; slow seepage; suitable for pit-type ponds.	High water table; fair to good stability; fair to good compaction characteristics; slow seepage.
Hillsdale: HlB, HlC	Medium to rapid seepage; seal blanket usually needed.	Fair stability; fair to good compaction characteristics; medium rate of seepage; some stones.
Houghton Mapped only in a complex with Adrian soils.	High water table; rapid seepage; suitable for pit-type ponds; flotation and caving in of organic matter likely.	Unstable organic material; high water table.
Iosco: IoA, IrA, IsB For Allendale part of IrA, see Allendale series. For Belding part of IsB, see Belding series.	Seasonal high water table; rapid seepage to a depth of 18 to 40 inches; slow to medium seepage at greater depths; seal blanket needed unless sandy material is removed.	Seasonal high water table; fair stability; fair compaction characteristics; slow to medium seepage below a depth of 18 to 40 inches.
Kalkaska: KaC	Rapid seepage; too porous to hold water unless a seal blanket is used.	Rapid seepage; fair stability; fair compaction characteristics; piping hazard; low shrink-swell potential.
Kawkawlin: KnA, KnB	Medium to slow seepage	Fair to good stability; poor compaction characteristics; slow seepage.
Kibbie: KoA, KoB	Medium to slow seepage; sides of ponds unstable when wet.	Subsoil has fair stability, fair compaction characteristics, and slow seepage. Substratum has poor stability and a medium rate of seepage and is subject to piping.
Lacota: La	High water table; rapid seepage in substratum; suitable for pit-type ponds.	High water table. Uppermost 18 to 40 inches has fair to good stability and slow seepage. Substratum has fair stability and rapid seepage and is subject to piping.
Lake beaches: Lb. Onsite investigation needed.		
Linwood: Ls	High water table; rapid seepage to a depth of 18 to 42 inches; slow seepage at greater depths; suitable for pit-type ponds; flotation of organic material possible.	High water table; 18 to 42 inches of unstable organic material; substratum has fair to poor compaction characteristics and fair stability.
Made land: Ma. Onsite investigation needed.		
Mancelona: McA, McB, McC	Medium to rapid seepage in subsoil; seal blanket needed if sand and gravel are exposed.	Uppermost 18 to 40 inches has fair stability, a medium rate of seepage, and fair to good compaction characteristics. Substratum has fair stability and rapid seepage and is subject to piping.

interpretations for farm uses—Continued

Soil properties affecting—Continued			
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
High water table; moderately slow permeability; wet depressions.	High available water capacity; medium rate of water intake: poor natural drainage.	Not needed: nearly level to depressional.	Not needed: nearly level to depressional.
Not needed	Moderate available water capacity; rapid water intake; runoff and erosion hazard in sloping areas.	Short, irregular slopes in some areas.	Easily eroded; strongly acid to very strongly acid.
High water table; organic material may settle if overdrained.	Very high available water capacity; very rapid water intake; poor natural drainage.	Not needed: nearly level to depressional.	Not needed: nearly level to depressional.
Seasonal high water table; moderately slow permeability below a depth of 18 to 40 inches; wet depressions.	Moderate available water capacity; very rapid water intake; seasonal high water table.	Not needed: level to gently sloping; slow runoff.	Normally not needed but may be used to remove surface water.
Not needed	Low available water capacity; very rapid water intake; hazard of soil blowing.	Not needed: sandy texture; short slopes; little runoff.	Sandy texture; short slopes; erosion hazard; low fertility; droughtiness; construction of waterways and establishment of vegetation are difficult.
Seasonal high water table; moderately slow permeability; wet depressions.	High available water capacity; medium rate of water intake.	Generally not needed: level to gently sloping; short, irregular slopes.	Seasonal high water table.
Seasonal high water table; substratum may flow into and plug drainage tile; ditchbanks unstable.	High available water capacity; medium rate of water intake.	Generally not needed: level to gently sloping; little runoff.	Seasonal high water table.
High water table; rapid permeability below a depth of 18 to 40 inches; wet depressions; sandy substratum makes blinding necessary.	Moderate available water capacity; medium rate of water intake; poor natural drainage.	Not needed: nearly level	Generally not needed.
High water table; organic material may settle if overdrained.	High available water capacity; very rapid water intake; very poor natural drainage.	Not needed: nearly level; slow runoff.	Not needed: nearly level.
Not needed	Low available water capacity; very rapid water intake; runoff and erosion hazard in sloping areas.	Slow to medium runoff; easily eroded. Avoid cuts into substratum.	Sandy texture; low fertility; droughtiness; easily eroded; difficult to establish vegetation.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil properties affecting—	
	Farm ponds	
	Reservoir area	Embankment
Marsh: Me. Onsite investigation needed.		
Matherton: MhA	Medium rate of seepage in subsoil; seal blanket needed if sand and gravel substratum is exposed.	Uppermost 24 to 40 inches has fair to good stability, fair to good compaction characteristics, and slow seepage. Substratum has fair stability, fair compaction characteristics, and rapid seepage.
Menominee: MmB, MmC	Rapid seepage to a depth of 18 to 40 inches; medium to slow seepage at greater depths; seal blanket needed unless sandy material is removed.	Fair stability; fair compaction characteristics; slow seepage; moderate to low shrink-swell potential.
Metamora: MnA, MnB	Medium to slow seepage	Fair to good stability; fair to good compaction characteristics; slow seepage.
Miami: MoB, MoC, MoD, MoF	Medium to slow seepage	Fair stability; fair compaction characteristics; slow seepage; moderate to low shrink-swell potential.
Montcalm: MrA, MrB, MrC	Rapid seepage; too porous to hold water unless a seal blanket is used.	Medium to rapid seepage; fair stability; fair compaction characteristics; piping hazard; low shrink-swell potential.
Morley: MtB, MtC2, MtE2, MuD3, MuF3	Slow seepage	Fair stability; poor to fair compaction characteristics; slow seepage; moderate shrink-swell potential.
Nester: NeB, NeC, NeD, NeE, NeF, NsC3, NsD3, NsE3, NsF3.	Slow seepage	Fair stability; poor to fair compaction characteristics; slow seepage; moderate shrink-swell potential.
Newaygo: NwB	Medium to rapid seepage in subsoil; seal blanket needed if sand and gravel are exposed.	Uppermost 24 to 40 inches has fair stability, fair to good compaction characteristics, and a medium rate of seepage. Substratum has good stability and rapid seepage and is subject to piping.
Oshtemo: OsA, OsB, OsC, OsD	Medium to rapid seepage in subsoil; seal blanket needed if sand and gravel are exposed.	Uppermost 40 to 66 inches has fair stability, fair to good compaction characteristics, and a medium rate of seepage. Substratum has good stability, rapid seepage, and very low compressibility.
Owosso: OwB	Medium to slow seepage	Fair to good stability; fair compaction characteristics; slow seepage.

interpretations for farm uses—Continued

Soil properties affecting—Continued			
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Seasonal high water table; moderate permeability to a depth of 24 to 40 inches; very rapid permeability at greater depths; blinding needed.	Moderate available water capacity; rapid water intake; sand and gravel at a depth of 24 to 40 inches.	Not needed: nearly level; slow runoff.	Nearly level; slow runoff; seasonal high water table.
Not needed	Moderate available water capacity; very rapid water intake; erosion hazard in sloping areas.	Sandy texture to a depth of 18 to 40 inches; difficult to work if cuts extend into clayey substratum.	Sandy texture to a depth of 18 to 40 inches; low fertility; droughtiness; easily eroded; difficult to establish vegetation.
Moderately slow permeability below a depth of 24 to 40 inches; seasonal high water table; wet depressions.	Moderate available water capacity; rapid water intake.	Generally not needed: level to gently sloping; slow runoff.	Seepage; seasonal high water table.
Not needed	High available water capacity; medium rate of water intake; erosion hazard in sloping to steep areas.	Irregular slopes in some areas; poor workability in subsoil.	Rapid runoff and erosion hazard in sloping to steep areas; difficult to establish vegetation if subsoil is exposed.
Not needed	Low available water capacity; rapid water intake; hazard of soil blowing.	Sandy texture; erosion hazard; irregular slopes in many areas.	Sandy texture; rapid permeability; slow to medium runoff; erosion hazard; establishing vegetation may be difficult.
Not needed except for random tile in small wet areas.	High available water capacity; medium rate of water intake; erosion hazard in sloping to steep areas.	Irregular slopes in some areas; poor workability in subsoil.	Rapid runoff and erosion hazard in sloping to steep areas; difficult to establish vegetation if subsoil is exposed.
Not needed except for random tile in small wet areas.	High available water capacity; medium rate of water intake; rapid runoff and erosion hazard in sloping to steep areas.	Irregular slopes in some areas; poor workability in subsoil.	Rapid runoff; erosion hazard; difficult to establish vegetation if subsoil is exposed.
Not needed	Moderate available water capacity; rapid water intake.	Short slopes. Avoid cuts into substratum.	No unfavorable properties.
Not needed	Low available water capacity; very rapid water intake; runoff and erosion hazard in sloping to moderately steep areas.	Slow to medium runoff; erosion hazard. Avoid cuts into substratum.	Sandy texture; low fertility; droughtiness; erosion hazard; difficult to establish vegetation.
Not needed except for random tile in small wet areas.	Moderate available water capacity; rapid water intake.	Short, irregular slopes in many areas.	Erosion hazard.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil properties affecting—	
	Farm ponds	
	Reservoir area	Embankment
Pinconning: Pn, Pr For Breckenridge part of Pr, see Breckenridge series.	Rapid seepage to a depth of 18 to 40 inches; slow seepage at greater depths.	Rapid seepage to a depth of 18 to 40 inches; slow seepage and low shrink-swell potential at greater depths; high water table.
Richter: RcA, RcB	Medium to rapid seepage; sides of ponds unstable when exposed.	Fair stability; fair to good compaction characteristics; medium rate of seepage.
Rubicon: RsB, RsD, RsF	Rapid seepage; too porous to hold water unless a seal blanket is used.	Rapid seepage; fair stability; fair compaction characteristics; piping hazard; low shrink-swell potential.
Sand pits: Sd. Onsite investigation needed.		
Saugatuck Mapped only in a complex with Au Gres soils.	Too porous to hold water unless a seal blanket is used.	Seasonal high water table; fair stability; fair compaction characteristics; rapid seepage; piping hazard.
Selkirk: SeA, SeB	Slow seepage	Seasonal high water table; fair stability; poor to fair compaction characteristics; slow seepage; high shrink-swell potential.
Shoals: Sh	Slow seepage; flood hazard	Seasonal high water table; fair to good stability; fair compaction characteristics; slow seepage.
Sims: Sm	High water table; slow seepage; suitable for pit-type ponds.	High water table; fair to good stability; poor to fair compaction characteristics; slow seepage.
Sloan: Sn	High water table; slow seepage; flood hazard; suitable for pit-type ponds.	High water table; fair to good stability; fair compaction characteristics; slow seepage.
Spinks: SpA, SpB, SpC, SsD, SsE, SsF For Montcalm part of SsD, SsE, and SsF, see Montcalm series.	Rapid seepage; too porous to hold water unless a seal blanket is used.	Medium to rapid seepage; fair stability; fair compaction characteristics; piping hazard; low shrink-swell potential.
Toledo: Tc	High water table; slow seepage; suitable for pit-type ponds.	High water table; fair stability; poor to fair compaction characteristics; slow seepage; high shrink-swell potential.
Tonkey: To	High water table; medium rate of seepage; suitable for pit-type ponds; sides of ponds unstable when wet.	Subsoil has fair stability and slow seepage. Substratum has poor stability and a medium rate of seepage and is subject to piping. High water table.

interpretations for farm uses—Continued

Soil properties affecting—Continued			
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Slow permeability below a depth of 18 to 40 inches; high water table.	Moderate available water capacity; very rapid water intake; slow permeability below a depth of 18 to 40 inches; poor natural drainage.	Not needed: nearly level; slow runoff.	Not needed: nearly level; slow runoff.
Seasonal high water table; pockets of sandy material; ditchbanks unstable; soil may flow into and plug tile lines.	Moderate available water capacity; rapid water intake.	Generally not needed: sandy texture; little runoff.	Seasonal high water table.
Not needed	Very low available water capacity; very rapid water intake; hazard of soil blowing.	Not needed: sandy texture; little runoff.	Sandy texture; very low fertility; droughtiness; erosion hazard; construction of waterways and establishment of vegetation are difficult.
Sandy texture to a depth of 60 inches; slowly permeable cemented layer below sand; wet depressions; ditchbanks unstable; feasibility of tiling questionable.	Low available water capacity; very rapid water intake.	Generally not needed: sandy texture; little runoff.	Generally not needed: sandy texture; little runoff.
Slow permeability; seasonal high water table; blinding needed.	Moderate available water capacity; medium rate of water intake; slow permeability.	Generally not needed: short, irregular slopes.	Seasonal high water table; fine-textured subsoil.
Seasonal high water table; flood hazard.	High available water capacity; medium rate of water intake; seasonal high water table; flood hazard.	Not needed: nearly level	Generally not needed.
High water table; moderately slow permeability; wet depressions.	High available water capacity; medium rate of water intake; poor natural drainage.	Not needed: nearly level	High water table; moderately fine textured subsoil and substratum.
High water table; flood hazard	High available water capacity; medium rate of water intake; flood hazard; poor natural drainage.	Not needed: nearly level	Generally not needed.
Not needed	Low available water capacity; rapid water intake; hazard of soil blowing.	Sandy texture; irregular slopes in many areas.	Rapid permeability; slow to medium runoff; erosion hazard; establishing vegetation may be difficult.
Slow permeability; high water table; blinding needed.	High available water capacity; slow water intake; slow permeability; poor natural drainage.	Not needed: nearly level	High water table; moderately fine to fine texture; construction may be difficult when soil is wet.
High water table; substratum may flow into and plug tile lines; ditchbanks unstable.	Moderate available water capacity; medium rate of water intake; poor natural drainage.	Not needed: nearly level	High water table.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil properties affecting—	
	Farm ponds	
	Reservoir area	Embankment
Tuscola: TsB	Medium rate of seepage; seal blanket needed; sides of ponds unstable if substratum is exposed.	Uppermost 30 to 46 inches has fair to good stability, fair compaction characteristics, and slow seepage. Substratum has poor to fair stability and is subject to piping.
Ubly: UlA, UlB, UlC	Medium to slow seepage	Fair to good stability; fair to good compaction characteristics; slow seepage.
Wallkill: Wa	High water table; slow seepage to a depth of 10 to 40 inches; rapid permeability at greater depths; flood hazard; suitable for pit-type ponds.	High water table; unstable organic substratum at a depth of 10 to 40 inches.
Warners: Wm	High water table; rapid seepage to a depth of less than 12 inches; slow seepage at greater depths; suitable for pit-type ponds.	High water table; less than 12 inches of unstable organic material over marl; marl has fair stability and poor compaction characteristics.
Wasepi: WsA	Medium rate of seepage to a depth of 24 to 40 inches; seal blanket needed if sand and gravel are exposed.	Uppermost 24 to 40 inches has fair stability, fair to good compaction characteristics, and a medium rate of seepage. Substratum has fair stability; fair compaction characteristics, and rapid seepage.
Washtenaw: Wt	High water table; medium rate of seepage; suitable for pit-type ponds.	High water table; fair to good stability; poor to fair compaction characteristics; slow seepage.
Wind eroded land, sloping: WuC. Onsite investigation needed.		

interpretations for farm uses—Continued

Soil properties affecting—Continued			
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Not needed	High available water capacity; medium rate of water intake.	Short, irregular slopes in many areas.	Erosion hazard.
Not needed	Moderate available water capacity; rapid water intake; runoff and erosion hazard in sloping areas.	Short, irregular slopes in many areas.	No unfavorable properties except erosion hazard in sloping areas.
High water table; flood hazard; organic material below a depth of 10 to 40 inches is unstable and may settle if drained.	High available water capacity; medium rate of water intake; flood hazard; poor natural drainage.	Not needed: nearly level to depressional.	Nearly level; high water table; construction and seeding difficult.
High water table; organic material settles if overdrained; marl at a depth of less than 12 inches.	High available water capacity; very rapid water intake; very poor natural drainage.	Not needed: nearly level to depressional.	Not needed.
Seasonal high water table; sand and gravel in substratum make blinding necessary.	Low available water capacity; rapid water intake; sand and gravel at a depth of 24 to 40 inches.	Not needed: nearly level; slow runoff.	Nearly level; slow runoff; low available water capacity; erosion hazard.
High water table; flood hazard; wet depressions.	High available water capacity; medium rate of water intake; flood hazard; poor natural drainage.	Not needed: nearly level to depressional.	Nearly level to depressional; high water table.

The ratings for sand and gravel refer to the availability of commercially useful material within 5 feet of the surface. In some soils that have suitable material within a depth of 5 feet, the material below that depth is unsuitable, and in some soils that are rated as unsuitable, sand and gravel do occur below a depth of 5 feet and can be located by digging test pits.

Suitability as a source of road fill depends partly on texture. If the subsoil and the substratum have contrasting characteristics, both are rated. Sand that contains adequate binder is the most suitable material, and clay and organic material are the least suitable. No specific values should be inferred from estimates of bearing capacity given in this column.

The ratings for impermeable material refer to compacted soil material. Examples of uses are linings for reservoirs and sewage lagoons and fill for dams.

For highway location, the properties of the entire profile, undisturbed and without artificial drainage, have to be considered. The State Highway Department of Michigan has rated the major soils of the State with respect to their highway engineering properties (*4*). No specific values should be inferred from estimates of bearing capacity given in this column.

Foundations for low buildings generally are based in the substratum, and the properties listed are those of that layer, in its undisturbed condition. Shrink-swell potential (see table 4) is the major factor to be considered.

Winter grading is affected mainly by texture, natural water content, and depth to the water table. These properties determine whether or not the soil can be handled easily and whether or not it can be traversed by ordinary construction equipment in winter.

Corrosion potential refers to the hazard of damage to underground conduits by corrosion resulting from soil properties. Generally, the soil properties that cause corrosion of metal conduits are poor aeration, high acidity, high electrical conductivity, high salt content, and high moisture content. Those that cause corrosion of concrete conduits are low acidity and a high moisture content.

The properties considered in judging the degree of limitation for use as a sewage disposal field were topography, permeability (or percolation rate), depth to the water table, and the flood hazard. A rating of slight indicates that there are no limitations that cannot easily be overcome; a rating of moderate, that limitations can be overcome with good management and careful design; and a rating of severe, that such use of the soil is questionable.

In table 6 the soil properties described in table 4 are interpreted in relation to farm uses. Explanations of the columns in table 6 follow.

The properties of the entire profile have to be considered in evaluating a soil as a location for a farm pond. Organic-matter content, permeability, depth to bedrock, shrink-swell potential, depth to the water table, strength, and stability are the significant properties. The properties of the soil before it is disturbed affect the reservoir area; those of the soil after it is disturbed affect embankments.

The properties that affect the installation and functioning of farm drainage systems are texture, water-intake rate, permeability, topography, depth to the water table, and depth to a restricting layer.

Water-intake rate and available water capacity are the properties most significant in evaluating a soil for irrigation. Also important are topography, depth to the water table, and depth to a restricting layer.

The properties that affect the layout and construction of terraces and diversions are texture, topography, and depth to layers unfavorable for crops.

Among the properties that affect the layout and construction of grassed waterways and the establishment, growth, and maintenance of suitable vegetation are permeability, fertility, and the erosion hazard.

Soil Properties in Relation to Town and Country Planning

Community development, with the accompanying extension of public utilities and establishment of business and recreational facilities, creates a need for soil information somewhat different from that needed for purposes of farming. Land appraisers, realtors, city planners, builders, and others need facts that will help them determine what sites are suitable for homes and other buildings and what areas are best reserved for other uses. Homeowners want information that will help them in landscaping their property and protecting it against the erosion hazards of built-up communities.

Residences.—Drainage, permeability, slope, erosion hazard, stability, and frequency of flooding have to be considered in evaluating the suitability of a site for an individual home or for a subdivision.

Homes built on soils that are poorly drained and have a high water table, such as those of the Breckenridge, Hettinger, and Sims series, are likely to have wet basements unless some artificial drainage is provided. A high water table, even if only seasonal, keeps sewage disposal systems from functioning properly. The soil descriptions (pages 8 to 67) give information about drainage and the occurrence of a high water table. Table 4 shows the depth to the seasonal high water table for the soils of all the series.

Permeability is another property that affects the functioning of sewage disposal systems. If the filter field is in rapidly or very rapidly permeable soils, such as those of the Chelsea, Spinks, and Rubicon series, unfiltered effluent may contaminate the water in shallow wells. Soils that are moderately or moderately slowly permeable, such as those of the Miami, Owosso, and Ubly series, provide more adequate filtering. Table 4 gives estimates of permeability rates for all the soils, and table 5 shows the kind and degree of limitations of the soils as locations for sewage disposal fields.

Shrink-swell potential is among the soil properties that affect suitability for foundations of low buildings. Boyer, Fox, and Hillsdale soils, which have a low shrink-swell potential and also have other favorable properties, provide good foundations. Organic soils, such as those of the Carlisle, Edwards, and Wallkill series, are not stable enough to be good for foundations. Table 4 gives estimates of shrink-swell potential for all the soils, and table 5 includes engineering interpretations that help in identifying the soils that are suitable for foundations.

Soils on bottom lands are subject to flooding and consequently are not good choices for building sites. Algansee, Ceresco, Cohoctah, Glendora, Shoals, and Sloan soils are examples.

Erosion and the accumulation of sediment are serious hazards where construction is underway. As a result of paving and of compaction of soil material, runoff from a built-up area is two to ten times as heavy as runoff from the same area while it was still in farms or forest. The runoff water concentrates in streets and gutters, instead of flowing into natural waterways, and the results are flooding and deposition of sediment in lower areas. The steeper the slope, the more severe the hazard. The sloping and steep soils of the Miami, Morley, Hillsdale, and Nester series are particularly susceptible to erosion. Table 6 includes interpretations relating to the construction of diversions and grassed waterways and the installation of drainage facilities. Measures that can be taken to control erosion in small residential tracts include the following:

1. Building driveways, walks, and fences on the contour or, if that is not possible, straight across the slope.
2. Grading to make the surface level or gently sloping. The surface layer can be removed before grading and used later for topsoil.
3. Building diversions that will intercept runoff and keep it from flowing over erodible areas.
4. Constructing waterways or improving existing waterways in order to prevent gullying.
5. Draining seepage areas and waterlogged areas with tile or other facilities.

Streets, driveways, sidewalks, and patios.—Of special interest to homeowners and developers are soil properties that cause cracking and shifting of pavement. Soils high in silt, such as those of the Bruce, Kibbie, and Tuscola series, are subject to frost heaving. Concrete placed on such soils cracks readily unless the surface of the soils is first covered with sand and gravel. Other properties that cause pavement to crack and shift excessively are a high water table and clayey texture. Pavement laid on very poorly drained organic soils, such as those of the Adrian, Carlisle, Edwards, and Warners series, is likely to crack and become uneven as a result of settling of the organic material after drainage. Table 4 gives estimates of shrink-swell potential for all the soils, and table 5 includes interpretations relating to the use of the soils for road fill and locations for highways; this information can be used to identify the soils that are unsuitable for streets, driveways, sidewalks, and patios.

Underground utility lines.—Water mains, gas pipelines, communication lines, and sewer lines that are buried in the ground may corrode and break unless protected against certain electrobiochemical reactions that result from inherent properties of the soils but differ according to the nature of the soils. All metals corrode to some degree if placed underground, and some metals corrode more rapidly in some soils than in others. The corrosion potential depends on physical, chemical, electrical, and biological properties of the soils—for example, oxygen concentration, concentration of anaerobic bacteria, and moisture content. Design and construction of the lines are also important. The likelihood of corrosion is intensified by connecting dissimilar metals, by burying metal structures at varying depths, and by extending pipelines through different kinds of soils. Table 5 gives the corrosion potential of all the soils of the county, for uncoated steel and for concrete.

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If cast-iron pipes are used, stress caused by shrinking and swelling of the soils is an additional hazard. In soils that have a high shrink-swell potential, cast-iron pipes may break unless cushioned with sandy material. Estimates of shrink-swell potential for all the soils are given in table 4.

Gardening and landscaping.—The ideal soils for yards and gardens are those that have a deep root zone, a loamy texture, a balanced supply of plant nutrients, an adequate amount of organic matter, adequate available water capacity, good drainage, and a structure that allows free movement of water. Fox, Hillsdale, Miami, and Tuscola soils closely approximate this ideal. On droughty soils, such as those of the Boyer, Chelsea, Mancelona, Rubicon, and Spinks series, lawn grasses and shrubs have to be watered frequently in dry weather. Poorly drained soils, such as those of the Sims and Toledo series, are difficult to work when wet and become hard and cloddy as they dry out. If such soils are disturbed by construction operations, seeding them with lawn grasses is difficult.

Other information useful in landscaping is given in the section "Capability Grouping."

Public health.—Soils information has applications to many public health problems, including those of sewage disposal, trash disposal, prevention of disease, and maintenance of safe and adequate water supplies.

Sewage lagoons, septic tank systems, and sewer lines need to be located and constructed so that seepage or drainage from them cannot pollute water supplies. One cause of pollution is leakage from sewage lagoons built on unsuitable soils, such as the rapidly permeable Chelsea, Rubicon, and Spinks soils. Wells, streams, and lakes can become contaminated by runoff from clogged and improperly located filter fields. The soil map, which shows the major drainageways of the county, can be used as a guide in locating filter fields where they will not cause pollution. Rapid percolation of septic tank effluent can result in pollution of shallow underground water supplies. Table 6 includes interpretations helpful in identifying soils that should not be used as material for construction of lagoons or as locations for filter fields.

In selecting sites for sanitary land fills, it is important to consider topography, drainage, soil texture, permeability, reaction, and the nature of the underlying material. Table 4 gives estimates of the pertinent properties of the soils. The soil map can be used to locate areas of suitable soils.

Stability of the soils is of major importance in selecting locations for sewer lines. If the gradeline is interrupted and the system breaks down, a public health hazard results. The shrink-swell potential of a soil (see table 4) is an indication of its relative stability. Corrosion is another cause of breakdowns in sewer lines. Estimates of the corrosion potential of all the soils are given in table 5.

Mosquitoes, fleas, and other disease-carrying insects breed in stagnant water. By the use of the soil descriptions and the soil map, it is possible to identify areas subject to flooding or ponding. Once the possible trouble spots are located, the health hazard can be controlled by spraying to eliminate insects and by installing drainage systems to remove standing water.

Formation and Classification of the Soils[7]

This section discusses the five major factors of soil formation, the processes involved in the differentiation of soil horizons, and the system of classifying soils and the placement of the soils of Ottawa County according to that system.

Factors of Soil Formation

Soil forms through the action of certain forces on material deposited or accumulated through geologic processes. The characteristics of the soil at any given point depend upon five major factors: parent material, climate, living organisms, topography, and time. The effect of each of these factors is conditioned by the other four factors, and a difference in any one results in the formation of a different kind of soil.

Climate and vegetation are the active factors in soil formation; their effects on the accumulated parent material bring about the formation of a soil with genetically related horizons.

The effects of climate and vegetation are conditioned by topography and time and also by the nature of the parent material. In some cases the parent material is the dominant factor in determining the characteristics of the soil.

Parent material.—Parent material is the unconsolidated mass from which a soil forms. It determines the limits of the inorganic chemical and mineralogical composition of the soil. The parent material of the soils of Ottawa County includes gravelly, sandy, loamy, clayey, and organic material. Most of the soils formed in material deposited by glaciers. Exceptions are the sandy soils along Lake Michigan, which formed in wind-deposited material; the alluvial soils on flood plains; and the organic soils, which were derived from decaying vegetation. Mancelona and Newaygo soils, for example, formed in sandy and gravelly glacial material; Deer Park soils, mainly in sandy wind-deposited material; Miami and Nester soils, in loamy glacial material; Toledo soils, in clayey glacial material; Sloan soils, in loamy alluvial material; and Carlisle and Houghton soils, in organic material.

Climate.—The climate of Ottawa County is cool and humid. Presumably the climate that existed while the soils were forming was similar. The influence of Lake Michigan affects the vegetation in a narrow belt along the lakeshore. Otherwise, the climate is about the same throughout the county, and generally speaking it does not account for significant differences among the soils.

Living organisms.—Plants, animals, insects, bacteria, and fungi are responsible for gains and losses in organic matter, nitrogen, and plant nutrients and for changes in structure and porosity. Vegetation, dominantly hardwood and coniferous trees, has affected the soils of Ottawa County more than other living organisms. Decayed plant material contributes organic matter to the soils, and the organic matter imparts a dark color to the surface layer. Granby soils are examples of soils that have a dark-colored surface layer as a result of the accumulation of organic matter.

Topography.—Topography affects soil formation through its influence on drainage, erosion, plant cover, and soil temperature. The topography of Ottawa County ranges from steep to depressional. There are steep areas in which local differences in relief are as much as 150 to 200 feet, undulating and hilly areas interspersed with small level areas, extensive plains that have slopes of less than 2 percent, and poorly drained depressions. Level and nearly level areas receive runoff from the slopes. Deer Park soils are examples of soils that commonly occur where the local differences in relief are sharp; Nester, Kawkawlin, and Sims soils are among those that occur where the landscape is predominantly undulating and hilly; Granby soils, which are poorly drained or very poorly drained, are examples of soils that occur on the broad plains; Wallkill soils are examples of depressional soils that have a high water table; and Allendale soils are among the level and nearly level soils that receive runoff from surrounding slopes.

Time.—Differences in the length of time the parent material has been in place commonly are reflected in the degree and distinctness of horizon differentiation. Usually a long period of time is needed for the formation of distinct textural horizons, but differences in organic-matter content become apparent in a shorter period of time.

The soils of Ottawa County have been forming for periods ranging from a few years to 10,000 years. The older soils have well-expressed horizons; some of the youngest show very little differentiation of horizons. Deer Park soils, for example, are young soils on sand dunes; except for a darker color in the surface layer, these soils retain most of the characteristics of their parent material. Rubicon soils are older and have better differentiated horizons.

Processes of Horizon Differentiation

Several processes were involved in the formation of horizons in the soils of Ottawa County. These processes are accumulation of organic matter, leaching of calcium carbonates and bases, reduction and transfer of iron, and formation and translocation of silicate clay materials. Most of the soils have been affected by more than one of these processes.

Accumulation of organic matter in the upper part of the profile to form an A1 horizon has been important. The range in organic-matter content is from very low to high.

Leaching of carbonates and bases has taken place in nearly all the soils. Soil scientists generally agree that leaching of bases usually precedes translocation of silicate clay minerals. Most of the soils are moderately to strongly leached. Nester soils, for example, have been leached of carbonates to a depth of about 28 inches.

Reduction and transfer of iron, a process called gleying, is evident in the poorly drained and very poorly drained soils. Gray colors in the subsoil indicate reduction and loss of iron. Some horizons have reddish-brown mottles

[7] By R. W. JOHNSON, soil correlator, Soil Conservation Service, with the assistance of E. P. WHITESIDE, Michigan Agricultural Experiment Station.

and concretions, which indicate a segregation of iron. The subsurface layer of the Tonkey soils is an example.

Translocation of clay minerals has contributed to horizon differentiation in some soils. In such soils the eluviated A2 horizon commonly has weak structure and is lower in content of clay and generally lighter in color than the B horizon. The B horizon has an accumulation of clay and probably was leached of carbonates and soluble salts to a considerable extent before translocation of silicate clay took place. Miami soils are examples of soils in which silicate clay minerals have accumulated in the B horizon.

In some soils of Ottawa County, iron and humus have moved from the surface to the B horizon. The color of the B horizon in such soils ranges from dark reddish brown to yellowish brown. Kalkaska, Rubicon, and Saugatuck soils are examples of soils that have an accumulation of translocated iron and humus in the subsoil.

Classification of the Soils

Soils are classified so that we may more readily remember their significant characteristics, assemble knowledge about them, see their relationships to one another and to the whole environment, and develop principles that help us to understand their behavior and response to manipulation. Through classification and the use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The current system of soil classification (*6*, *9*) is designed to accommodate all soils. It defines classes of soils in terms of observable or measurable properties. The properties chosen are primarily those that result in the grouping of soils of similar genesis, or mode of origin. Genesis does not, however, appear in the definitions of the classes. This system, adopted by the National Cooperative Soil Survey in 1965, replaced the system that had been in use since 1938 (*2*, *7*).

The system of classification now in use has six catgories. Beginning with the most inclusive, the categories are the order, the suborder, the great group, the subgroup, the family, and the series. Table 7 shows the classification of the soils of Ottawa County according to this system. This classification is in effect as of January 1970; it is subject to change as more precise information becomes available. Some of the soils do not fit exactly into any established series but closely resemble the soils of one of the established series, differing from them only in small ways that are not of consequence in interpreting usefulness and behavior. Such soils are given the name of an appropriate series and are known as taxadjuncts to that series. The taxadjuncts in Ottawa County are identified in table 7 with footnote references, and the ways in which they differ from typical soils of the series are explained in footnotes at the end of the table. Brief descriptions of the six categories follow.

ORDER.—Ten soil orders are recognized: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate orders are those that tend to give broad climatic groupings of soils. Two exceptions to this generalization are the Entisols and the Histosols, both of which occur in many different climates. Six of the ten orders are represented in Ottawa County: Entisols, Inceptisols, Alfisols, Mollisols, Spodosols, and Histosols.

Entisols are recent soils. They either lack genetic horizons or are only beginning to develop them.

Inceptisols occur most commonly on young but not recent land surfaces. Some of the soils that, under the system used until 1965, were classified as Alluvial soils and some that were classified as Low-Humic Gley soils are in this order.

Alfisols have a clay-enriched B horizon that is high in base saturation. Some of the soils formerly classified as Gray-Brown Podzolic soils and as Gray Wooded soils are in this order.

Mollisols have a fairly thick, dark-colored, mineral surface layer. Some of the soils formerly classified as Alluvial soils and some formerly classified as Humic Gley soils are in this order.

Spodosols have a B horizon enriched with iron and humus. Some of the soils formerly classified as Podzols are in this order.

Histosols develop from organic material. Soils formerly classified as muck, peat, organic soils, and bog soils are in this order.

SUBORDER.—Each order is divided into suborders, mainly on the basis of soil characteristics that result in grouping soils according to genetic similarity. The climatic range is narrower than that of the order. The properties used are mainly those that reflect either the presence or absence of waterlogging or differences in climate or vegetation.

GREAT GROUP.—Each suborder is divided into great groups on the basis of similarity in the kind and sequence of major horizons and in major soil properties. The horizons considered are those in which clay, iron, or humus has accumulated and those in which pans that interfere with the growth of roots and the movement of water have formed. The properties are soil temperature, chemical composition (mainly base saturation with calcium, magnesium, sodium, and potassium), and the like. (In table 7, this category is not shown separately; the last word in the name of the subgroup is the name of the great group.)

SUBGROUP.—Each great group is divided into subgroups; one represents the central (typic) concept of the group, and the others, called intergrades, have one or more properties of another great group, suborder, or order.

FAMILY.—Families are established within each subgroup, primarily on the basis of properties important to the growth of plants or properties significant in engineering. Texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence are among the properties considered.

SERIES.—A series is a group of soils that have horizons similar in all important characteristics, except for texture of the surface layer, and that are similar in arrangement in the profile. (See the section "How This Survey Was Made.")

TABLE 7.—*Classification of soil series by higher categories*

Series	Family	Subgroup	Order
Adrian	(1)	(1)	Histosols.
Algansee	Mixed, mesic	Aquic Udipsamments	Entisols.
Allendale [2]	Sandy over clayey, mixed, frigid	Aqualfic Haplorthods	Spodosols.
Au Gres [3]	Sandy, mixed, frigid	Entic Haplaquods	Spodosols.
Belding [3]	Coarse-loamy, mixed, frigid	Alfic Haplaquods	Spodosols.
Blount	Fine, illitic, mesic	Aeric Ochraqualfs	Alfisols.
Bowers [3]	Fine, mixed	Aquic Eutroboralfs	Alfisols.
Boyer	Coarse-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Breckenridge [3]	Coarse-loamy, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Brevort [3]	Sandy over loamy, mixed, nonacid, frigid	Mollic Haplaquents	Entisols.
Bruce [3]	Fine-loamy, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Carlisle	(1)	(1)	Histosols.
Ceresco	Coarse-loamy, mixed, mesic	Aquic Fluventic Hapludolls	Mollisols.
Chelsea	Mixed, mesic	Alfic Udipsamments	Entisols.
Cohoctah	Coarse-loamy, mixed, noncalcareous, mesic	Fluventic Haplaquolls	Mollisols.
Conover	Fine-loamy, mixed, mesic	Udollic Ochraqualfs	Alfisols.
Croswell [3]	Sandy, mixed, frigid	Entic Haplorthods	Spodosols.
Deer Park [3]	Mixed, frigid	Spodic Udipsamments	Entisols.
Edwards	(1)	(1)	Histosols.
Fox	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludalfs	Alfisols.
Gilford	Coarse-loamy, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Gladwin [3]	Sandy, mixed, frigid	Alfic Haplaquods	Spodosols.
Glendora	Mixed, mesic	Mollic Psammaquents	Entisols.
Granby	Sandy, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Hettinger [3]	Fine-loamy, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Hillsdale	Coarse-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Houghton	(1)	(1)	Histosols.
Iosco [3]	Sandy over loamy, mixed, frigid	Aqualfic Haplorthods	Spodosols.
Kalkaska [3]	Sandy, mixed, frigid	Typic Haplorthods	Spodosols.
Kawkawlin [3]	Fine, mixed	Aquic Eutroboralfs	Alfisols.
Kibbie	Fine-loamy, mixed, mesic	Aquollic Hapludalfs	Alfisols.
Lacota [3]	Fine-loamy over sandy or sandy-skeletal, mixed, nonacid, frigid.	Mollic Haplaquepts	Inceptisols.
Linwood	(1)	(1)	Histosols.
Mancelona [3]	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Matherton	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Udollic Ochraqualfs	Alfisols.
Menominee [3]	Sandy over loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Metamora	Fine-loamy, mixed, mesic	Udollic Ochraqualfs	Alfisols.
Miami	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Montcalm [3]	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Morley	Fine, illitic, mesic	Typic Hapludalfs	Alfisols.
Nester [3]	Fine, mixed	Typic Eutroboralfs	Alfisols.
Newaygo [3]	Fine-loamy over sandy or sandy-skeletal, mixed, frigid	Alfic Haplorthods	Spodosols.
Oshtemo	Coarse-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Owosso	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Pinconning [3]	Sandy over clayey, mixed, nonacid, frigid	Mollic Haplaquents	Entisols.
Richter [3]	Coarse-loamy, mixed, frigid	Alfic Haplaquods	Spodosols.
Rubicon [3]	Sandy, mixed, frigid	Entic Haplorthods	Spodosols.
Saugatuck	Sandy, mixed, mesic, ortstein	Aeric Haplaquods	Spodosols.
Selkirk [3]	Fine, illitic	Aquic Eutroboralfs	Alfisols.
Shoals	Fine-loamy, mixed, nonacid, mesic	Aeric Fluventic Haplaquepts	Inceptisols.
Sims [4]	Fine, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Sloan	Fine-loamy, mixed, noncalcareous, mesic	Fluventic Haplaquolls	Mollisols.
Spinks	Sandy, mixed, mesic	Psammentic Hapludalfs	Alfisols.
Toledo	Fine, illitic, nonacid, mesic	Mollic Haplaquepts	Inceptisols.
Tonkey [4]	Coarse-loamy, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Tuscola	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Ubly [3]	Coarse-loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Wallkill	Fine-loamy, mixed, nonacid, mesic	Thapto-Histic Haplaquepts	Inceptisols.
Warners [5]	Fine-silty, mixed, calcareous, mesic	Typic Haplaquolls	Mollisols.
Wasepi	Coarse-loamy, mixed, mesic	Aquollic Hapludalfs	Alfisols.
Washtenaw	Fine-loamy, mixed, nonacid, mesic	Typic Haplaquents	Entisols.

[1] Classification of Histosols at the subgroup and family levels was provisional at the time this survey was ready for printing.

[2] Taxadjunct. Wetter than typical; average soil temperature lower than 47° F.

[3] Taxadjunct. Average soil temperature lower than 47° F.

[4] Taxadjunct. Colors not typical of Mollic Haplaquepts; average soil temperature higher than 47° F.

[5] Taxadjunct. Mineral surface layer lacking.

Climate[8]

Ottawa County is on the eastern shore of Lake Michigan. Westerly winds prevail, so the flow of air generally is from the lake. The lake has a moderating effect on the weather throughout the county but most noticeably in the western part. Extremely high and extremely low temperatures are rare. Spring is late because the cold lake water chills the incoming air. After warming up during summer, the water stays warm long enough to modify the first outbreaks of cold weather in fall. Summer is pleasant because of the cool lake breezes. Winter temperatures are mild, but snow flurries are frequent and the average total snowfall is heavy. Climatological data for the county are given in tables 8, 9, and 10.

The highest temperature of record is 101° F., recorded on July 21, 1934; at no other time on record has the temperature reached 100°. The lowest temperature of record is −25° F., recorded on February 11, 1899. On the average, temperatures of more than 90° occur only three times in a summer and below-zero temperatures only twice in a winter. The highest mean monthly temperature of record is 76.4°, which occurred in August 1947 and July 1955.

[8] NORTON D. STROMMEN, climatologist for Michigan, National Weather Service, U.S. Department of Commerce, helped prepare this section.

TABLE 8.—*Temperature and precipitation data*

[Based on U.S. National Weather Service records kept at Grand Haven, Ottawa County, Mich. Period of record, 1935–64]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—		Days with snow cover	Average depth of snow on days with snow cover an inch or more deep
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	31. 6	19. 5	44	5	2. 15	1. 0	3. 5	20	6. 9
February	33. 1	19. 4	45	5	1. 78	. 8	2. 9	17	8. 3
March	41. 9	26. 5	60	13	2. 14	. 9	3. 7	8	4. 1
April	54. 6	36. 3	72	25	2. 86	1. 2	5. 4	0	----------
May	66. 1	45. 7	81	35	3. 18	1. 3	5. 4	0	----------
June	75. 5	55. 8	87	45	3. 20	1. 2	5. 7	0	----------
July	80. 1	61. 2	89	51	2. 67	1. 1	5. 6	0	----------
August	79. 1	60. 5	88	50	2. 95	1. 4	4. 8	0	----------
September	72. 1	53. 1	85	39	3. 29	1. 3	5. 8	0	----------
October	61. 8	43. 7	74	31	2. 48	. 9	4. 5	(1)	(2)
November	47. 0	33. 6	62	21	2. 69	1. 4	4. 1	4	3. 8
December	35. 4	23. 9	50	11	2. 19	1. 0	3. 5	14	6. 5
Year	56. 5	39. 9	[3] 91	[4] −2	31. 58	24. 2	39. 3	63	6. 6

[1] Less than half a day.
[2] Less than ½ inch.
[3] Average annual maximum.
[4] Average annual minimum.

TABLE 9.—*Probabilities of last freezing temperatures in spring and first in fall*

[These dates are calculated from records kept at Grand Haven and apply to the western part of the county. For the eastern part of the county, calculate 3 to 5 days later in spring and 3 to 5 days earlier in fall]

Probability	Date for given probability and temperature				
	16°F. or lower	20°F. or lower	24°F. or lower	28°F. or lower	32°F. or lower
Spring:					
1 year in 10 later than	March 29	April 8	April 17	May 5	May 21
2 years in 10 later than	March 24	April 4	April 12	May 1	May 16
5 years in 10 later than	March 14	March 24	April 2	April 20	May 6
Fall:					
1 year in 10 earlier than	November 22	November 13	November 1	October 16	September 27
2 years in 10 earlier than	November 27	November 18	November 6	October 21	October 2
5 years in 10 earlier than	December 8	November 29	November 17	November 1	October 13

TABLE 10.—*Probability of snow cover of specified depth before given dates*

[At Grand Haven. Based on depth of snow cover at time of daily observation]

Probability	Depth of snow cover			
	1 inch	3 inches	6 inches	12 inches
5 percent	November 1	November 11	November 4	December 4
10 percent	November 6	November 16	November 21	December 13
30 percent	November 18	November 27	December 5	January 2
50 percent	November 26	December 5	December 14	January 4
70 percent	December 4	December 13	December 23	(1)
90 percent	December 16	December 24	January 7	(1)

[1] Probability less than given percent.

The growing season averages 160 days. At Grand Haven, the average date of the last freezing temperature in spring is May 6 and the average date of the first freeze in fall is October 13. In the eastern part of the county, the dates are 3 to 5 days later in spring and 3 to 5 days earlier in fall.

More than half the annual precipitation—an average of 57 percent—falls during the 6-month period April through September (see table 8). September is the month of the heaviest average precipitation, and February the month of the lightest. The wettest month of record was September 1892, when precipitation totaled 9.37 inches. The driest month of record was November 1904, when precipitation measured only a trace. About once in 2 years, as much as 1.3 inches of rain falls in an hour, as much as 1.6 inches in 2 hours, and as much as 2.5 inches in 24 hours. About once in 10 years, as much as 3.7 inches falls in 24 hours, and once in 50 years, as much as 4.6 inches.

Data recorded at South Haven, about 25 miles south of Ottawa County, indicates that the average total evaporation (class A pan) between the first of April and the end of October is 36.51 inches, which is more than twice the average total rainfall for the six-month period. The deficit is made up from water stored in the soils since the rains of winter and early spring.

Snowfall averages 66 inches a year but varies considerably from year to year. In the last 35 years, annual totals have ranged from as much as 121 inches, in the 1935–36 season, to as little as 15 inches, in the 1948–49 season. Measurable amounts of snow usually fall each month from October through April.

Cloudy days are most common late in fall and early in winter and least common late in spring and in summer. The nearest National Weather Service stations at which records of cloudiness are kept are at Grand Rapids, which is to the east, and at Muskegon, which is to the northwest. At Grand Rapids, December averages 23 cloudy days, 6 partly cloudy days, and 2 clear days; July averages 10 cloudy days, 12 partly cloudly days, and 9 clear days. At Muskegon, December averages 25 cloudy days, 4 partly cloudy days, and 2 clear days; July averages 8 cloudy days, 11 partly cloudy days, and 12 clear days.

Geology and Physiography[9]

The bedrock of Ottawa County consists of the edges of bowllike rock formations that fill the Michigan basin. The oldest rock is the Coldwater Shale (*3*), which underlies all the county and is near the surface along the western edge. Overlapping the Coldwater Shale in the central part of the county is the Marshall Formation, which is, in turn, overlapped in the northeastern part of the county by the Michigan Formation.

Overlying these rocks is a mass of glacial drift deposited during the Wisconsin glacial period. When the ice melted, some 8 to 12 thousand years ago, it left deposits of raw soil material that ranged from less than 100 to more than 300 feet in thickness. Such deposits covered all of the area that is now Ottawa County. The present surface features are, for the most part, the results of glacial action.

Physiographically, the county is located in the Great Lakes Plains. Variations in relief within the county are not great. The elevation at the shore of Lake Michigan is about 580 feet, and the highest elevation in the county is slightly more than 800 feet. Local differences in elevation exceed 150 feet in only a few places.

The topographic features of the county include nearly level plains, which are in part well drained and in part wet and swampy; high dunes; low, short, narrow sand ridges, rounded hills, and constructional valleys and basins; and low bluffs and escarpments. Three well-defined topographic divisions are recognized: a broad, low-lying sandy plain, which occupies the western half of the county and extends eastward through the center of the county as a V-shaped area; a gently sloping to hilly upland, which occupies the southeastern quarter of the county; and a gently sloping to rolling upland plain, which occupies the northeastern quarter. The low-lying plain probably represents the bed of Lake Chicago, a glacial lake now extinct. It is no more than 60 to 75 feet higher than Lake Michigan. The upland and the upland plain are 100 to 250 feet higher than Lake Michigan.

The most conspicuous topographic feature of the county is the line of sand dunes that extends the entire length of the shore front. These dunes, some as much as 200 feet in height, form a broken ridge half a mile to a mile wide.

[9] WILLIAM ALLRED and W. W. STUDLEY, Soil Conservation Service, helped prepare this section.

In some places they are covered with a dense stand of maple, beech, red oak, hemlock, and white pine; in other places they are barren.

Other topographic features are prominent locally. On the low-lying lake plain are three plateaulike areas that represent detached parts of the upland; one of these is near Holland, one is in the southern part of Olive Township, and one is north of Hudsonville. Two deltalike plains of sand and gravel occur; one is in and around Allendale, and the other is near Zeeland. A narrow valley extends from near Zeeland northeastward to Hudsonville and merges into the terraced plain of the Grand River near the eastern boundary of the county. The floor of this valley is 50 to 100 feet below the general level of the upland, and the valley sides are fairly abrupt, particularly near Hudsonville. Probably this valley was the channel of the Grand River during parts of the glacial periods. Two long, narrow valleys dissect the northeastern upland and divide it into three plateaulike strips. Hilly and broken topography characterizes the southern and southeastern parts of the county.

Streams are few in relation to the land area and are particularly scarce in the western part of the county. The streams lack a systematic pattern and direction of flow, and, as is characteristic of glaciated regions, some small streams occupy relatively deep and broad valleys.

Water Supply[10]

An abundance of water is one of Ottawa County's most valuable assets. Three water-distribution pipelines convey Lake Michigan water to the larger cities and towns in the southern part of the county and also to the cities of Grand Rapids and Wyoming in Kent County. Shallow and deep wells provide ample water for domestic uses, for livestock, and for irrigation. More than 200 farm ponds store water for livestock and for fire protection and also provide recreational opportunities.

Lake Michigan, Spring Lake, Lake Macatawa, Pigeon Lake, and the numerous bayous along the Grand River are important as recreational areas and tourist attractions.

Farm Statistics[11]

Various farming enterprises are carried on in Ottawa County, the choice in any given area depending largely on the nature of the soils. In the western part of the county, where sandy soils are common, the major products are Christmas trees and other timber products, blueberries, truck crops, and sod. In the central and southeastern parts of the county, the soils are well suited to hay, corn, oats, and wheat, and dairying and general farming predominate. The organic soils near Zeeland and Hudsonville are used largely for celery, onions, and other truck crops. Fruit crops are important in the northeastern part of the county and to a lesser degree in the central part. Poultry and nursery stock are other important farm products.

There were 2,260 farms in the county in 1964. Of these, 791 were between 1 acre and 49 acres in size, 740 between 50 and 99 acres, 644 between 100 and 259 acres, 78 between 260 and 499 acres, 6 between 500 and 999 acres, and 1 more than 1,000 acres.

Classified according to the main enterprise, 546 were dairy farms, 346 were poultry or livestock farms other than dairy, 117 were vegetable farms, 171 were fruit and nut farms, 109 were general farms, and 971 were miscelleaneous or unclassified farms.

Corn is the row crop most extensively grown in the county. In 1964 corn for grain was harvested from 23,529 acres and corn for silage from 8,300 acres. In the same year wheat was grown on 14,194 acres, oats on 10,327 acres, barley on 648 acres, and rye on 464 acres. Of the hay crops, alfalfa and alfalfa mixtures were grown on 21,542 acres, clover or timothy on 7,930 acres, and other hay crops on 728 acres. Alfalfa and red clover seed were harvested from 915 acres. Potatoes were grown on 242 acres, and beans on 113 acres.

Tree fruits, grapes, and nuts were grown on 4,483 acres in 1964, and vegetables for sale on 3,957 acres. Of fruits harvested, there were 36,359,579 pounds of apples; 2,931,768 pounds of peaches; 980,443 pounds of pears; 1,293,512 pounds of plums and prunes; 2,609,571 pounds of cherries; and 35,811 pounds of grapes. Other fruits grown for sale included 283,843 pounds of strawberries, 105,541 pounds of raspberries, and 6,450,864 pounds of blueberries.

One million board feet of saw logs, 273 cords of firewood and fuel wood, and 199,186 Christmas trees were sold in 1964. Nursery products were produced on 57 farms; cut flowers, potted plants, florist greens, and bedding plants on 70 farms; and hothouse vegetables, flower seeds, vegetable seeds, plants, bulbs, and mushrooms on 39 farms.

Poultry and poultry products accounted for about 27.5 percent of the total value of farm products sold in 1964; dairy products for about 24 percent; other livestock products and field crops for about 17.5 percent; fruits and nuts for about 14.6 percent; vegetables for about 7.8 percent; and forest products and horticultural specialties for about 8.5 percent.

All statistics in this section are from the U.S. Census of Agriculture for 1964.

[10, 11] WILLIAM ALLRED and W. W. STUDLEY, Soil Conservation Service, helped prepare this section.

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Glossary

Acidity. See Reaction, soil.

Aggregate. Many fine particles held in a single mass or cluster, such as a clod, a crumb, a block, or a prism.

Alkalinity. See Reaction, soil.

Alluvium. Soil material that has been deposited on land by streams.

Available water capacity. The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. Also called available moisture capacity.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: Clay coat, clay skin.

Concretions. Hard grains, pellets, or nodules of various sizes, shapes, and colors, consisting of concentrations of compounds or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose. Noncoherent; will not hold together in a mass.

Friable. When moist, crushes easily under gentle to moderate pressure between thumb and forefinger and can be pressed together in a lump.

Firm. When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic. When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.

Contour farming. Plowing, cultivating, planting, and harvesting in rows that are at right angles to the natural direction of the slope or that are parallel to the terrace grade.

Contour stripcropping. Growing crops in strips that follow the contour or are parallel to terraces or diversions. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Cover crop. A close-growing crop grown primarily to improve the soil and to protect it between periods of regular crop production.

Diversion. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and thus to protect areas downslope from the effects of such runoff.

Drainage, artificial. The removal of excess water on or within the soil by means of surface or subsurface drains.

Drainage, natural. Refers to the conditions that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage of irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. The following five classes of natural drainage are recognized in Ottawa County.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum; they have uniform color in the A and the upper part of the B horizon and are mottled in the lower part of the B horizon and in the C horizon.

Somewhat poorly drained soils are wet for significant periods but not all the time; the water table is within 12 to 24 inches of the surface during part of the year; mottling occurs below a depth of 6 to 16 inches, in the lower part of the A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods; they are light gray and generally are mottled from the surface downward but may be free of mottling or nearly so.

Very poorly drained soils are wet nearly all the time; they have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the lower part of the profile.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors, such as light, moisture, temperature, and the physical condition of the soil, are favorable.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Fragipan. A loamy, brittle, subsurface horizon that is very low in organic matter and clay but is rich in silt or very fine sand. The layer is seemingly cemented. When dry, it is hard or very hard and has a high bulk density in comparison with the horizon or horizons above it. When moist, the fragipan tends to rupture suddenly if pressure is applied, rather than to deform slowly. The layer is generally mottled, is slowly or very slowly permeable to water, and has few or many bleached fracture planes that form polygons. Fragipans are a few inches to several feet thick; they generally occur below the B horizon, 15 to 40 inches below the surface.

Gravel. Rounded pebbles 2 millimeters to 3 inches in diameter.

Green manure. A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of the following: soluble salts, clay, or sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sequioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Mineral soil. Soil composed mainly of inorganic (mineral) material and low in content of organic matter. Its bulk density is greater than that of an organic soil.

Mottled. Irregularly marked with spots of a different color. Mottles vary in number and size. Their presence usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent. The size measurements are these: Fine, less than 5

millimeters (about 0.2 inch) in diameter along the greatest dimension; medium, ranging from 5 millimeters to 15 millimeters (about 0.2 to about 0.6 inch) in diameter along the greatest dimension; and coarse, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Muck. An organic soil consisting of fairly well decomposed organic material that is relatively high in mineral content, finely divided, and dark colored.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color that has a hue of 10YR, a value of 6, and a chroma of 4.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

Organic soil. A general term applied to a soil or to a soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers.

Parent material, soil. The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Peat. Unconsolidated soil material, largely undecomposed organic matter that has accumulated where there has been excess moisture.

Ped. A natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: Very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid.

Percolation. The downward movement of water through soil.

pH. A numerical means for designating relative acidity and alkalinity in soils. See also Reaction, soil.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. See also Horizon, soil.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed as a pH value. A pH of 7.0 indicates a neutral reaction; a higher pH indicates alkalinity, and a lower pH, acidity. The various degrees of acidity and alkalinity are expressed in words as follows:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff. Water that flows off the land surface and into streams without sinking into the soil.

Sand. As a soil separate, individual rock or mineral fragments that range from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be of any mineral composition. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slope. The inclination of the land surface from the horizontal. To get the percentage of slope, divide the vertical distance by the horizontal distance and multiply by 100. Thus, a slope of 10 percent is a drop of 10 feet in 100 feet of horizontal distance.

Soil. A natural three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: Very coarse sand (2.0 millimeters to 1.0 millimeter); coarse sand (1.0 to 0.5 millimeter); medium sand (0.5 to 0.25 millimeter); fine sand (0.25 to 0.10 millimeter); very fine sand (0.10 to 0.05 millimeter); silt (0.05 to 0.002 millimeter); and clay (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in a mature soil consists of the A and B horizons. Generally, the characteristics of the soil material in these horizons are unlike those of the underlying parent material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Stratified. Composed of, or arranged in, strata, or layers, such as stratified alluvium. The term is confined to geological material. Layers that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), blocky (angular or subangular), and granular. Structureless soils are (1) single grain (each grain by itself, as in dune sand) or (2) massive (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer lying beneath the solum, or true soil; the C horizon.

Subsurface layer. As used in this survey, that part of the A horizon that is directly below the surface layer. It is leached of soluble minerals and clay.

Surface layer. As used in this survey, that part of the A horizon that occurs at the surface. This layer contains an accumulation of organic matter and generally is dark colored.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. See also Clay, Sand, and Silt. The basic textural classes, in order of increasing proportions of fine particles, are as follows: Sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Trace elements. Chemical elements found in soils in extremely small amounts but essential to plant growth. Some of the trace elements are zinc, cobalt, manganese, and copper.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table is separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit or woodland suitability group, read the introduction to the section it is in for general information about its management. The symbol in parentheses following the capability unit symbol identifies the soil management group of the Michigan State system in which the mapping unit belongs. Other information is given in tables as follows:

Acreage and extent, table 1, page 9.
Predicted yields table 2, page 79.
Suitability of soils for wildlife habitat, table 3, page 86.
Engineering uses of soils, tables 4, 5, and 6, pages 92 through 129.

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Symbol	Page
Ad	Adrian muck	10	IVw-5 (M/4c)	76	U	85
Ah	Adrian-Houghton mucks	10				
	Adrian part	--	IVw-5 (M/4c)	76	U	85
	Houghton part	--	IVw-5 (Mc)	76	U	85
Ak	Algansee loamy sand	11	IIIw-14 (L-4c)	74	O	84
AlA	Allendale sandy loam, 0 to 4 percent slopes	11	IIIw-7 (4/1b)	72	G	83
AmB	Au Gres loamy sand, 0 to 6 percent slopes	13	IVw-2 (5b)	75	F	83
ArB	Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes 1/	13	IVw-2 (5b)	75	F	83
AsB	Au Gres-Saugatuck sands, 0 to 6 percent slopes	13				
	Au Gres part	--	IVw-3 (5b)	76	F	83
	Saugatuck part	--	IVw-3 (5b-h)	76	F	83
BeA	Belding sandy loam, 0 to 2 percent slopes	14	IIw-8 (3/2b)	70	G	83
BeB	Belding sandy loam, 2 to 6 percent slopes	15	IIw-8 (3/2b)	70	G	83
BlA	Blount loam, 0 to 2 percent slopes	16	IIw-2 (1.5b)	69	Z	86
BlB	Blount loam, 2 to 6 percent slopes	16	IIw-3 (1.5b)	70	Z	86
BoB	Blown-out land, 0 to 6 percent slopes	16	VIIs-1 (5.3a)	77	Y	85
BoF	Blown-out land, 6 to 50 percent slopes	16	VIIs-1 (5.3a)	77	Y	85
BpA	Bowers loam, 0 to 2 percent slopes	17	IIw-2 (1.5b)	69	Z	86
BpB	Bowers loam, 2 to 6 percent slopes	17	IIw-3 (1.5b)	70	Z	86
BrA	Boyer loamy sand, 0 to 2 percent slopes	17	IIIs-3 (4a)	74	M	84
BrB	Boyer loamy sand, 2 to 6 percent slopes	18	IIIs-4 (4a)	74	M	84
BrC	Boyer loamy sand, 6 to 12 percent slopes	18	IIIe-9 (4a)	71	M	84
Bu	Breckenridge sandy loam	19	IIw-8 (3/2c)	72	W	85
Bv	Brevort sandy loam	20	IIIw-10 (4/2c)	73	W	85
By	Bruce loam	20	IIw-6 (2.5c)	70	W	85
Cc	Carlisle muck	21	IIIw-15 (Mc)	74	U	85
Ce	Ceresco loam	21	IIIw-12 (L-2c)	73	O	84
ChB	Chelsea loamy sand, 0 to 6 percent slopes	22	IVs-4 (5a)	76	E	83
ChC	Chelsea loamy sand, 6 to 12 percent slopes	22	VIs-1 (5a)	77	E	83
ClB	Chelsea complex, 0 to 6 percent slopes	23	IVs-4 (5a)	76	E	83
Cm	Cohoctah loam	23	IIIw-12 (L-2c)	73	O	84
CnB	Conover loam, 2 to 6 percent slopes	24	IIw-3 (2.5b)	70	Z	86
CrB	Croswell sand, 0 to 6 percent slopes	25	IVs-4 (5a)	76	E	83
CwB	Croswell and Au Gres sands, 0 to 6 percent slopes	25				
	Croswell part	--	IVs-4 (5a)	76	E	83
	Au Gres part	--	IVs-4 (5b)	76	F	83
DpB	Deer Park sand, 0 to 6 percent slopes	25	VIIs-1 (5.3a)	77	H	83
DpD	Deer Park sand, 6 to 18 percent slopes	26	VIIs-1 (5.3a)	77	H	83
DpF	Deer Park sand, 18 to 45 percent slopes	26	VIIs-1 (5.3a)	77	H	83
Ed	Edwards muck	26	IVw-6 (M/mc)	76	U	85
FoB	Fox sandy loam, 0 to 6 percent slopes	27	IIs-2 (3a)	70	K	84
Gd	Gilford sandy loam	28	IIIw-6 (4c)	72	W	85
GeA	Gladwin sandy loam, 0 to 2 percent slopes	29	IIIw-5 (4b)	72	F	83
GeB	Gladwin sandy loam, 2 to 6 percent slopes	29	IIIw-5 (4b)	72	F	83
Gl	Glendora sandy loam	30	IIIw-14 (L-4c)	74	O	84
Gm	Granby loamy sand	30	IIIw-11 (5c)	73	Q	84
Gn	Granby fine sandy loam	30	IIIw-11 (5c)	73	Q	84
Gr	Gravel pits	31	VIIIs-1 (Sa)	77	--	--

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Symbol	Page
Hg	Hettinger loam	31	IIw-2 (1.5c)	69	P	84
HlB	Hillsdale sandy loam, 2 to 6 percent slopes	32	IIe-3 (3a)	69	K	84
HlC	Hillsdale sandy loam, 6 to 12 percent slopes	32	IIIe-5 (3a)	71	K	84
IoA	Iosco loamy sand, 0 to 4 percent slopes	34	IIIw-9 (4/2b)	73	G	83
IrA	Iosco and Allendale loamy sands, 0 to 4 percent slopes	34				
	Iosco part	--	IIIw-9 (4/2b)	73	G	83
	Allendale part	--	IIIw-9 (4/1b)	73	G	83
IsB	Iosco-Belding complex, 2 to 6 percent slopes	34				
	Iosco part	--	IIIw-9 (4/2b)	73	G	83
	Belding part	--	IIIw-9 (3/2b)	73	G	83
KaC	Kalkaska sand, 0 to 12 percent slopes	35	IVs-4 (5a)	76	H	83
KnA	Kawkawlin loam, 0 to 2 percent slopes	36	IIw-2 (1.5b)	69	Z	86
KnB	Kawkawlin loam, 2 to 6 percent slopes	36	IIw-3 (1.5b)	70	Z	86
KoA	Kibbie loam, 0 to 2 percent slopes	37	IIw-6 (2.5b)	70	G	83
KoB	Kibbie loam, 2 to 6 percent slopes	37	IIw-7 (2.5b)	70	G	83
La	Lacota silt loam	38	IIw-6 (3c)	70	W	85
Lb	Lake beaches	38	VIIIs-1 (Sa)	77	Y	85
Ls	Linwood muck	38	IIIw-15 (M/3c)	74	U	85
Ma	Made land	39	VIIIs-1 (Sa)	77	--	--
McA	Mancelona loamy sand, 0 to 2 percent slopes	39	IIIs-3 (4a)	74	C	83
McB	Mancelona loamy sand, 2 to 6 percent slopes	40	IIIs-4 (4a)	74	C	83
McC	Mancelona loamy sand, 6 to 12 percent slopes	40	IIIe-9 (4a)	71	C	83
Me	Marsh	41	VIIIw-2 (Sc)	77	U	85
MhA	Matherton loam, 0 to 2 percent slopes	41	IIw-6 (3b)	70	G	83
MmB	Menominee loamy sand, 2 to 6 percent slopes	42	IIIs-4 (4/2a)	74	C	83
MmC	Menominee loamy sand, 6 to 12 percent slopes	43	IIIe-9 (4/2a)	71	C	83
MnA	Metamora sandy loam, 0 to 2 percent slopes	43	IIw-8 (3/2b)	70	G	83
MnB	Metamora sandy loam, 2 to 6 percent slopes	44	IIw-8 (3/2b)	70	G	83
MoB	Miami loam, 2 to 6 percent slopes	44	IIe-2 (2.5a)	69	D	83
MoC	Miami loam, 6 to 12 percent slopes	44	IIIe-5 (2.5a)	71	D	83
MoD	Miami loam, 12 to 18 percent slopes	45	IVe-1 (2.5a)	75	D	83
MoF	Miami loam, 18 to 45 percent slopes	45	VIe-1 (2.5a)	77	D	83
MrA	Montcalm loamy sand, 0 to 2 percent slopes	46	IIIs-3 (4a)	74	C	83
MrB	Montcalm loamy sand, 2 to 6 percent slopes	46	IIIs-4 (4a)	74	C	83
MrC	Montcalm loamy sand, 6 to 12 percent slopes	46	IIIe-9 (4a)	71	C	83
MtB	Morley loam, 2 to 6 percent slopes	47	IIe-1 (1.5a)	69	B	82
MtC2	Morley loam, 6 to 12 percent slopes, eroded	47	IIIe-4 (1.5a)	71	B	82
MtE2	Morley loam, 18 to 25 percent slopes, eroded	47	VIe-1 (1.5a)	77	B	82
MuD3	Morley clay loam, 12 to 18 percent slopes, severely eroded	47	VIe-1 (1.5a)	77	B	82
MuF3	Morley clay loam, 25 to 45 percent slopes, severely eroded	47	VIIe-1 (1.5a)	77	B	82
NeB	Nester loam, 2 to 6 percent slopes	48	IIe-1 (1.5a)	69	B	82
NeC	Nester loam, 6 to 12 percent slopes	48	IIIe-4 (1.5a)	71	B	82
NeD	Nester loam, 12 to 18 percent slopes	49	IVe-1 (1.5a)	75	B	82
NeE	Nester loam, 18 to 25 percent slopes	49	VIe-1 (1.5a)	77	B	82
NeF	Nester loam, 25 to 45 percent slopes	49	VIIe-1 (1.5a)	77	B	82
NsC3	Nester clay loam, 6 to 12 percent slopes, severely eroded	49	IVe-3 (1.5a)	75	B	82
NsD3	Nester clay loam, 12 to 18 percent slopes, severely eroded	49	VIe-1 (1.5a)	77	B	82
NsE3	Nester clay loam, 18 to 25 percent slopes, severely eroded	49	VIIe-1 (1.5a)	77	B	82
NsF3	Nester clay loam, 25 to 45 percent slopes, severely eroded	50	VIIe-1 (1.5a)	77	B	82
NwB	Newaygo sandy loam, 0 to 6 percent slopes	50	IIs-2 (3a)	70	A	82
OsA	Oshtemo sandy loam, 0 to 2 percent slopes	51	IIIs-3 (4a)	74	M	84
OsB	Oshtemo sandy loam, 2 to 6 percent slopes	51	IIIs-4 (4a)	74	M	84
OsC	Oshtemo sandy loam, 6 to 12 percent slopes	51	IIIe-9 (4a)	71	M	84
OsD	Oshtemo sandy loam, 12 to 18 percent slopes	52	IVe-9 (4a)	75	M	84

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Symbol	Page
OwB	Owosso sandy loam, 2 to 6 percent slopes	52	IIe-3 (3/2a)	69	A	82
Pn	Pinconning loamy sand	53	IIIw-8 (4/1c)	72	W	85
Pr	Pinconning and Breckenridge sandy loams	53				
	Pinconning part	--	IIIw-8 (4/1c)	72	W	85
	Breckenridge part	--	IIIw-8 (3/2c)	72	W	85
RcA	Richter sandy loam, 0 to 2 percent slopes	54	IIw-6 (3b)	70	G	83
RcB	Richter sandy loam, 2 to 6 percent slopes	54	IIw-7 (3b)	70	G	83
RsB	Rubicon sand, 0 to 6 percent slopes	55	VIIs-1 (5.3a)	77	H	83
RsD	Rubicon sand, 6 to 18 percent slopes	55	VIIs-1 (5.3a)	77	H	83
RsF	Rubicon sand, 18 to 45 percent slopes	56	VIIs-1 (5.3a)	77	H	83
Sd	Sand pits	56	VIIIs-1 (Sa)	77	Y	85
SeA	Selkirk loam, 0 to 2 percent slopes	57	IIIw-2 (1b)	72	Z	86
SeB	Selkirk loam, 2 to 6 percent slopes	57	IIIw-2 (1b)	72	Z	86
Sh	Shoals loam	58	IIIw-12 (L-2c)	73	O	84
Sm	Sims loam	59	IIw-2 (1.5c)	69	P	84
Sn	Sloan loam	60	IIIw-12 (L-2c)	73	O	84
SpA	Spinks loamy sand, 0 to 2 percent slopes	60	IIIs-3 (4a)	74	E	83
SpB	Spinks loamy sand, 2 to 6 percent slopes	60	IIIs-4 (4a)	74	E	83
SpC	Spinks loamy sand, 6 to 12 percent slopes	61	IIIe-9 (4a)	71	E	83
SsD	Spinks and Montcalm loamy sands, 12 to 18 percent slopes	61				
	Spinks part	--	IVe-9 (4a)	75	E	83
	Montcalm part	--	IVe-9 (4a)	75	C	83
SsE	Spinks and Montcalm loamy sands, 18 to 25 percent slopes	61				
	Spinks part	--	VIs-1 (4a)	77	E	83
	Montcalm part	--	VIs-1 (4a)	77	C	83
SsF	Spinks and Montcalm loamy sands, 25 to 45 percent slopes	61				
	Spinks part	--	VIIe-2 (4a)	77	E	83
	Montcalm part	--	VIIe-2 (4a)	77	C	83
Tc	Toledo silty clay loam	62	IIIw-1 (1c)	71	P	84
To	Tonkey sandy loam	63	IIw-6 (3c)	70	W	85
TsB	Tuscola fine sandy loam, 2 to 6 percent slopes	63	IIe-2 (2.5a)	69	K	84
UlA	Ubly sandy loam, 0 to 2 percent slopes	64	IIs-2 (3/2a)	70	A	82
UlB	Ubly sandy loam, 2 to 6 percent slopes	64	IIe-3 (3/2a)	69	A	82
UlC	Ubly sandy loam, 6 to 12 percent slopes	64	IIIe-5 (3/2a)	71	A	82
Wa	Wallkill silt loam	65	IIIw-15 (L-2c)	74	U	85
Wm	Warners muck	66	IVw-6 (M/mc)	76	U	85
WsA	Wasepi sandy loam, 0 to 2 percent slopes	66	IIIw-5 (4b)	72	G	83
Wt	Washtenaw loam	67	IIIw-12 (L-2c)	73	P	84
WuC	Wind eroded land, sloping	67	VIIIs-1 (Sa)	77	Y	85

1/ This soil is known as Arenac loamy sand by the Michigan Agricultural Experiment Station.

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

MICHIGAN AGRICULTURAL EXPERIMENT STATION

OTTAWA COUNTY, MICHIGAN

GENERAL SOIL MAP

N

1 0 1 2 3 4 Miles
Scale 1:190,080

R 16 W | 86°10' | R 15 W | 86°00' | R 14 W | R 13 W | 85°50'

43°10'
T 9 N
T 8 N
T 7 N
T 6 N
T 5 N
42°50'

MUSKEGON COUNTY
OTTAWA COUNTY
KENT COUNTY
ALLEGAN COUNTY

LAKE MICHIGAN

SPRING LAKE
CROCKERY
WRIGHT
POLKTON
TALLMADGE
GRAND HAVEN
ROBINSON
ALLENDALE
CHESTER
OLIVE
BLENDON
GEORGETOWN
PORT SHELDON
HOLLAND
ZEELAND
JAMESTOWN
PARK

Harrisburg
Conklin
Ferrysburg
Munica
Coopersville
Herrington
Marne
Eastmanville
Lamont
Tallmadge
Allendale
Pearline
Agnew
West Olive
North Blendon
Bauer
Jenison
Crisp
Borculo
Blendon
New Holland
Hudsonville
Pine Creek Corners
Zeeland
Vriesland
Zutphen
Jamestown
Holland
Drenthe
Gitchel
Macatawa

Little Black L.
Crockery Cr.
Crockery Lake
Grand River
Spring Lake
Grand River
Crockery Cr.
Deer Creek
Sand Creek
Penn Central
Western
Bass Creek
Pigeon Creek
Black River
Chesapeake and Ohio
Macatawa Lake

SOIL ASSOCIATIONS*

1 — Rubicon-Blown-out land-Deer Park association: Level to steep, well-drained, sandy soils of the dunes and plains

2 — Rubicon-Granby-Croswell-Au Gres association: Level and gently sloping, well-drained to very poorly drained, sandy soils of the lake plains and outwash plains

3 — Granby-Au Gres-Saugatuck association: Nearly level and gently sloping, very poorly drained to somewhat poorly drained, sandy soils of the lake plains

4 — Nester-Kawkawlin-Sims association: Gently sloping to rolling, well-drained to poorly drained, loamy soils of the uplands

5 — Richter-Gilford-Gladwin association: Nearly level and gently sloping, somewhat poorly drained to very poorly drained, sandy and loamy soils of glacial drainageways

6 — Mancelona-Nester-Belding-Iosco association: Gently sloping to hilly, well-drained to somewhat poorly drained, sandy and loamy soils of the uplands

7 — Sloan-Adrian-Houghton association: Level, poorly drained, bottom land soils and organic soils

8 — Chelsea-Mancelona-Montcalm association: Level and gently sloping, well drained and moderately well drained, gravelly and sandy soils of outwash plains and terraces

9 — Blount-Morley-Kibbie association: Level and gently sloping, well-drained to somewhat poorly drained, loamy soils of uplands

10 — Miami-Hillsdale-Spinks association: Rolling and hilly, well-drained, loamy and sandy soils of the uplands

11 — Bowers-Hettinger-Nester association: Nearly level to gently sloping, well-drained to poorly drained, loamy soils of the lake plains

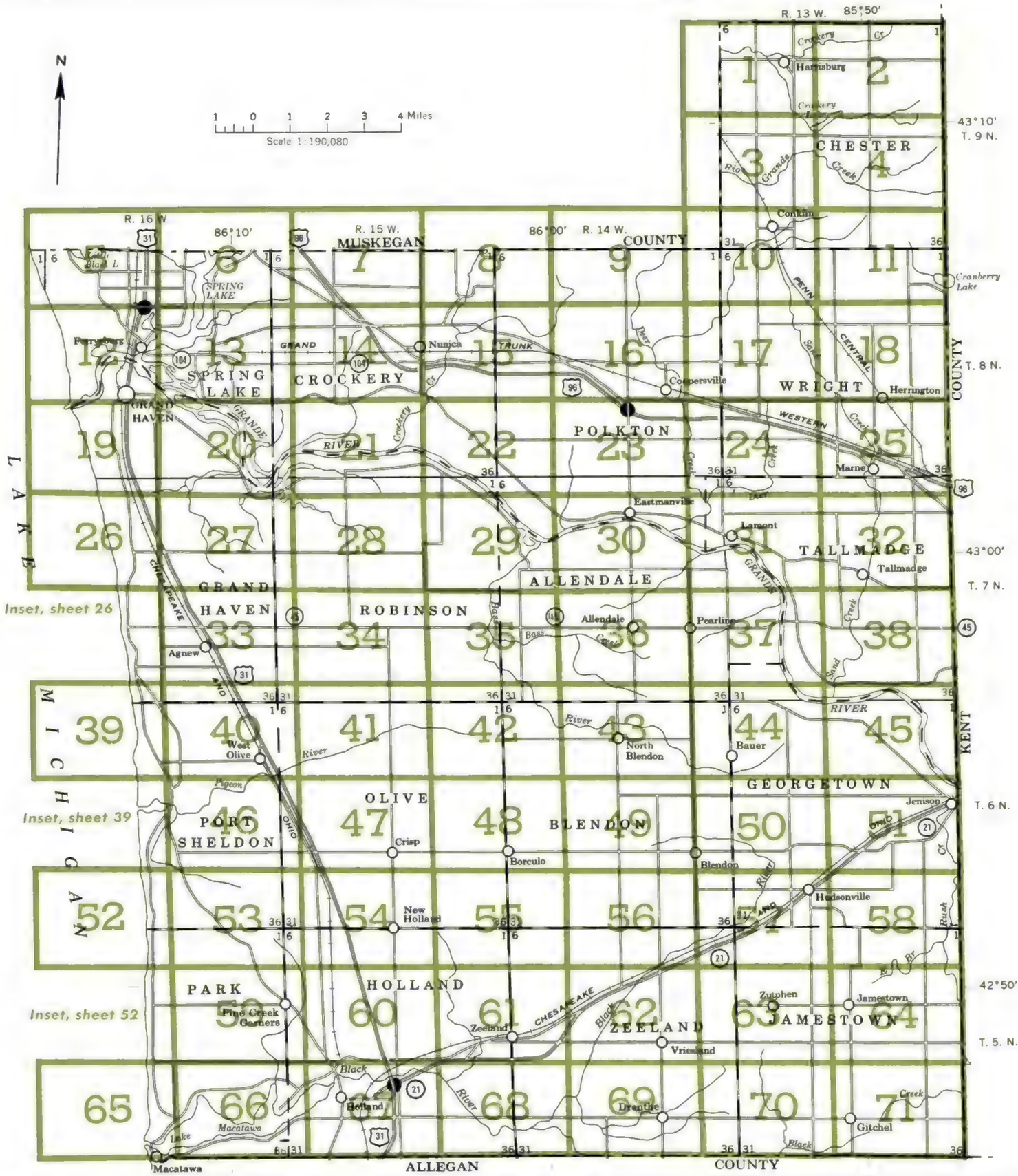
12 — Kawkawlin association: Gently sloping, somewhat poorly drained, loamy soils of the till plains

*Soil texture given in all the associations is that of the surface layer.

This map is for general planning. It shows only the major soils and does not contain sufficient detail for operational planning.

OTTAWA COUNTY, MICHIGAN

INDEX TO MAP SHEETS



SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Most symbols without a slope letter are those of nearly level soils, but some are for land types that have a considerable range in slope. A final number, 2 or 3, in the symbol shows that the soil is eroded or severely eroded.

SYMBOL	NAME
Ad	Adrian muck
Ah	Adrian-Houghton mucks
Ak	Algansee loamy sand
AlA	Allendale sandy loam, 0 to 4 percent slopes
AmB	Au Gres loamy sand, 0 to 6 percent slopes
ArB	Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes
AsB	Au Gres-Saugatuck sands, 0 to 6 percent slopes
BeA	Belding sandy loam, 0 to 2 percent slopes
BeB	Belding sandy loam, 2 to 6 percent slopes
BlA	Blount loam, 0 to 2 percent slopes
BlB	Blount loam, 2 to 6 percent slopes
BoB	Blown-out land, 0 to 6 percent slopes
BoF	Blown-out land, 6 to 50 percent slopes
BpA	Bowers loam, 0 to 2 percent slopes
BpB	Bowers loam, 2 to 6 percent slopes
BrA	Boyer loamy sand, 0 to 2 percent slopes
BrB	Boyer loamy sand, 2 to 6 percent slopes
BrC	Boyer loamy sand, 6 to 12 percent slopes
Bu	Breckenridge sandy loam
Bv	Brevort sandy loam
By	Bruce loam
Cc	Carlisle muck
Ce	Ceresco loam
ChB	Chelsea loamy sand, 0 to 6 percent slopes
ChC	Chelsea loamy sand, 6 to 12 percent slopes
ClB	Chelsea complex, 0 to 6 percent slopes
Cm	Cohoctah loam
CnB	Conover loam, 2 to 6 percent slopes
CrB	Croswell sand, 0 to 6 percent slopes
CwB	Croswell and Au Gres sands, 0 to 6 percent slopes
DpB	Deer Park sand, 0 to 6 percent slopes
DpD	Deer Park sand, 6 to 18 percent slopes
DpF	Deer Park sand, 18 to 45 percent slopes
Ed	Edwards muck
FoB	Fox sandy loam, 0 to 6 percent slopes
Gd	Gilford sandy loam
GeA	Gladwin sandy loam, 0 to 2 percent slopes
GeB	Gladwin sandy loam, 2 to 6 percent slopes
Gl	Glendora sandy loam
Gm	Granby loamy sand
Gn	Granby fine sandy loam
Gr	Gravel pits
Hg	Hettinger loam
HlB	Hillsdale sandy loam, 2 to 6 percent slopes
HlC	Hillsdale sandy loam, 6 to 12 percent slopes
IoA	Iosco loamy sand, 0 to 4 percent slopes
IrA	Iosco and Allendale loamy sands, 0 to 4 percent slopes
IsB	Iosco-Belding complex, 2 to 6 percent slopes
KaC	Kalkaska sand, 0 to 12 percent slopes
KnA	Kawkawlin loam, 0 to 2 percent slopes
KnB	Kawkawlin loam, 2 to 6 percent slopes
KoA	Kibbie loam, 0 to 2 percent slopes
KoB	Kibbie loam, 2 to 6 percent slopes
La	Lacota silt loam
Lb	Lake beaches
Ls	Linwood muck
Ma	Made land
McA	Mancelona loamy sand, 0 to 2 percent slopes
McB	Mancelona loamy sand, 2 to 6 percent slopes
McC	Mancelona loamy sand, 6 to 12 percent slopes
Me	Marsh
MhA	Matherton loam, 0 to 2 percent slopes
MmB	Menominee loamy sand, 2 to 6 percent slopes
MmC	Menominee loamy sand, 6 to 12 percent slopes
MnA	Metamora sandy loam, 0 to 2 percent slopes
MnB	Metamora sandy loam, 2 to 6 percent slopes
MoB	Miami loam, 2 to 6 percent slopes
MoC	Miami loam, 6 to 12 percent slopes
MoD	Miami loam, 12 to 18 percent slopes
MoF	Miami loam, 18 to 45 percent slopes
MrA	Montcalm loamy sand, 0 to 2 percent slopes
MrB	Montcalm loamy sand, 2 to 6 percent slopes
MrC	Montcalm loamy sand, 6 to 12 percent slopes
MtB	Morley loam, 2 to 6 percent slopes
MtC2	Morley loam, 6 to 12 percent slopes, eroded
MtE2	Morley loam, 18 to 25 percent slopes, eroded
MuD3	Morley clay loam, 12 to 18 percent slopes, severely eroded
MuF3	Morley clay loam, 25 to 45 percent slopes, severely eroded
NeB	Nester loam, 2 to 6 percent slopes
NeC	Nester loam, 6 to 12 percent slopes
NeD	Nester loam, 12 to 18 percent slopes
NeE	Nester loam, 18 to 25 percent slopes
NeF	Nester loam, 25 to 45 percent slopes
NsC3	Nester clay loam, 6 to 12 percent slopes, severely eroded
NsD3	Nester clay loam, 12 to 18 percent slopes, severely eroded
NsE3	Nester clay loam, 18 to 25 percent slopes, severely eroded
NsF3	Nester clay loam, 25 to 45 percent slopes, severely eroded
NwB	Newaygo sandy loam, 0 to 6 percent slopes
OsA	Oshtemo sandy loam, 0 to 2 percent slopes
OsB	Oshtemo sandy loam, 2 to 6 percent slopes
OsC	Oshtemo sandy loam, 6 to 12 percent slopes
OsD	Oshtemo sandy loam, 12 to 18 percent slopes
OwB	Owosso sandy loam, 2 to 6 percent slopes
Pn	Pinconning loamy sand
Pr	Pinconning and Breckenridge sandy loams
RcA	Richter sandy loam, 0 to 2 percent slopes
RcB	Richter sandy loam, 2 to 6 percent slopes
RsB	Rubicon sand, 0 to 6 percent slopes
RsD	Rubicon sand, 6 to 18 percent slopes
RsF	Rubicon sand, 18 to 45 percent slopes
Sd	Sand pits
SeA	Selkirk loam, 0 to 2 percent slopes
SeB	Selkirk loam, 2 to 6 percent slopes
Sh	Shoals loam
Sm	Sims loam
Sn	Sloan loam
SpA	Spinks loamy sand, 0 to 2 percent slopes
SpB	Spinks loamy sand, 2 to 6 percent slopes
SpC	Spinks loamy sand, 6 to 12 percent slopes
SsD	Spinks and Montcalm loamy sands, 12 to 18 percent slopes
SsE	Spinks and Montcalm loamy sands, 18 to 25 percent slopes
SsF	Spinks and Montcalm loamy sands, 25 to 45 percent slopes
Tc	Toledo silty clay loam
To	Tonkey sandy loam
TsB	Tuscola fine sandy loam, 2 to 6 percent slopes
UlA	Ubly sandy loam, 0 to 2 percent slopes
UlB	Ubly sandy loam, 2 to 6 percent slopes
UlC	Ubly sandy loam, 6 to 12 percent slopes
Wa	Wallkill silt loam
Wm	Warners muck
WsA	Wasepi sandy loam, 0 to 2 percent slopes
Wt	Washtenaw loam
WuC	Wind eroded land, sloping

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry (FY)
- Ford (FORD)
- Grade
- R. R. over
- R. R. under

Tunnel

Buildings
- School
- Church

Mine and quarry

Gravel pit

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Windmill

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches (CANAL)

Lakes and ponds
- Perennial (water, w)
- Intermittent

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

Depressions

	Large	Small
Crossable with tillage implements		
Not crossable with tillage implements		
Contains water most of the time		

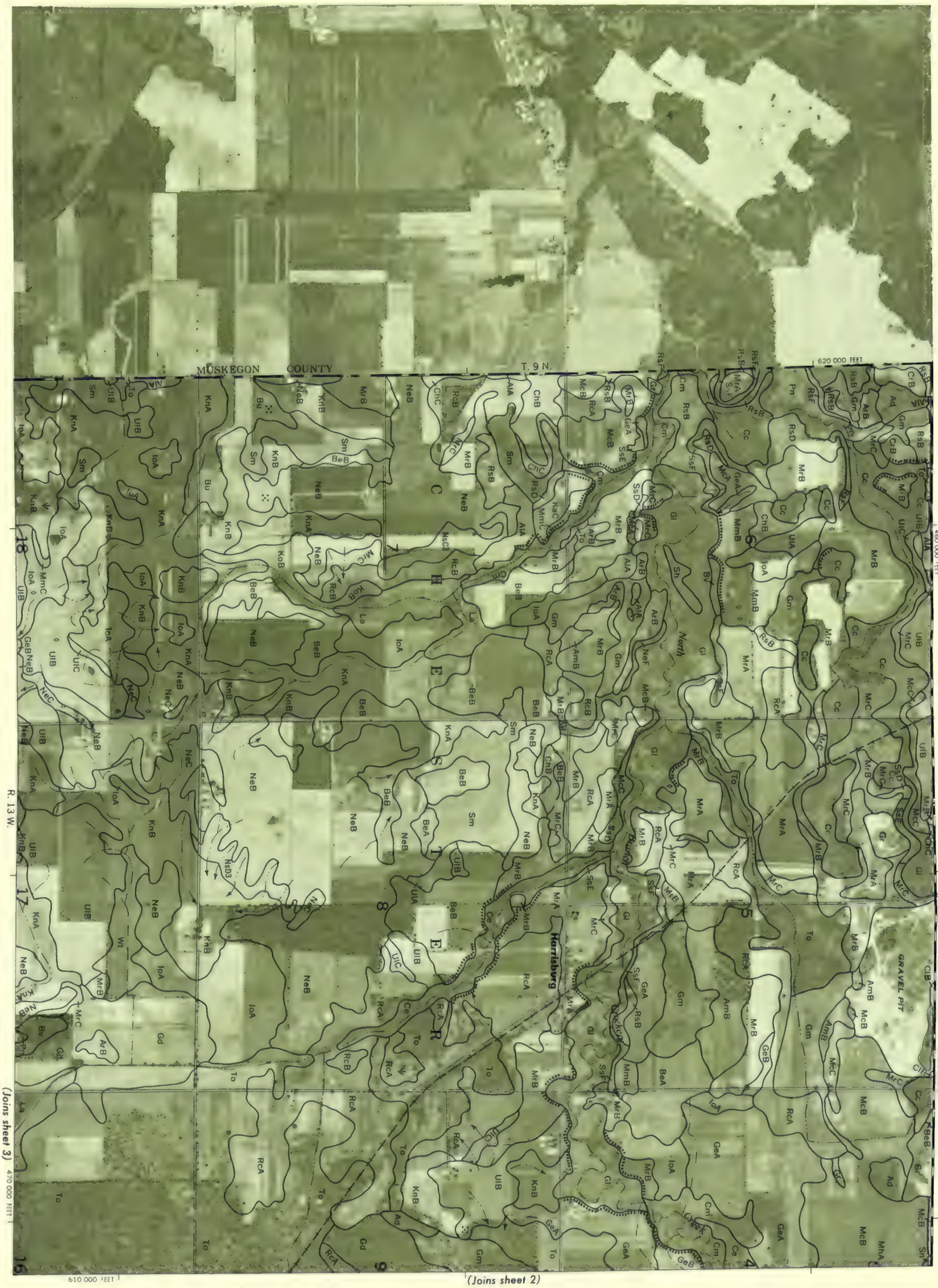
SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stoniness
  - Stony
  - Very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection. 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photograph

OTTAWA COUNTY, MICHIGAN NO. 1



(10)

OTTAWA COUNTY MICHIGAN — SHEET NUMBER 10

R. 14 W. | R. 13 W.

(Joins sheet 3)

N

1 Mile

5000 Feet

Scale 1:15840

OTTAWA COUNTY, MICHIGAN NO. 10

Land division corners are approximately positioned on this map.

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Plane coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photography.

R. 13 W. OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 11

(Joins sheet 4)

475 000 FEET

T. 9 N.

T. 8 N.

500 000 FEET

485 000 FEET

(Joins sheet 10)

(Joins sheet 18)

Big Springs School

St Joseph Church and School

Wright

CRANBERRY LAKE

MED LAKE

KENT COUNTY

11

N

1 Mile

5,000 Feet

Scale 1:15840

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Plane coordinate projection: 1927 North American datum. 5,000-foot grid ticks based on Michigan coordinate system central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN, NO. 11

12

OTTAWA COUNTY MICHIGAN — SHEET NUMBER 12

OTTAWA COUNTY, MICHIGAN NO. 12

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station

Plane coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system
central zone Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 13

(Joins sheet 6)

380 000 FEET

580 000 FEET

R. 16 W.

R. 15 W.

T. 8 N.

SPRING LAKE

SPRING LAKE CEMETERY

GOLF COURSE

TRUNK

GRAND

WESTERN

Smith Bayou

Hammond Bayou

Lloyds Bayou

GRAND RIVER

Intermittent

GRAND HAVEN (County seat)

Jeffers School

(Joins sheet 12)

(Joins sheet 14)

(Joins sheet 20)

395 000 FEET

570 000 FEET

13

N

1 Mile

5000 Feet

Scale 1:15840

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Plane coordinate projection 1927 North American datum. 5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN NO. 13

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 14

(14)

N

1 Mile

5,000 Feet

Scale 1:15840

0 0

1/4 1000

1/2 2000

3/4 3000

4000

5000

(Joins sheet 7)

(Joins sheet 13)

(Joins sheet 21)

(Joins sheet 15)

400 000 FEET

580 000 FEET

570 000 FEET

425 000 FEET

R. 15 W.

T. 8 N.

8 9 10

17 16 15

18 19 20 21 22

C R O C K E R Y

GRAND TRUNK WESTERN

Black Creek

WuC Creek

water

Nunica

OTTAWA COUNTY, MICHIGAN NO. 14

Land division corners are approximately positioned on this map.

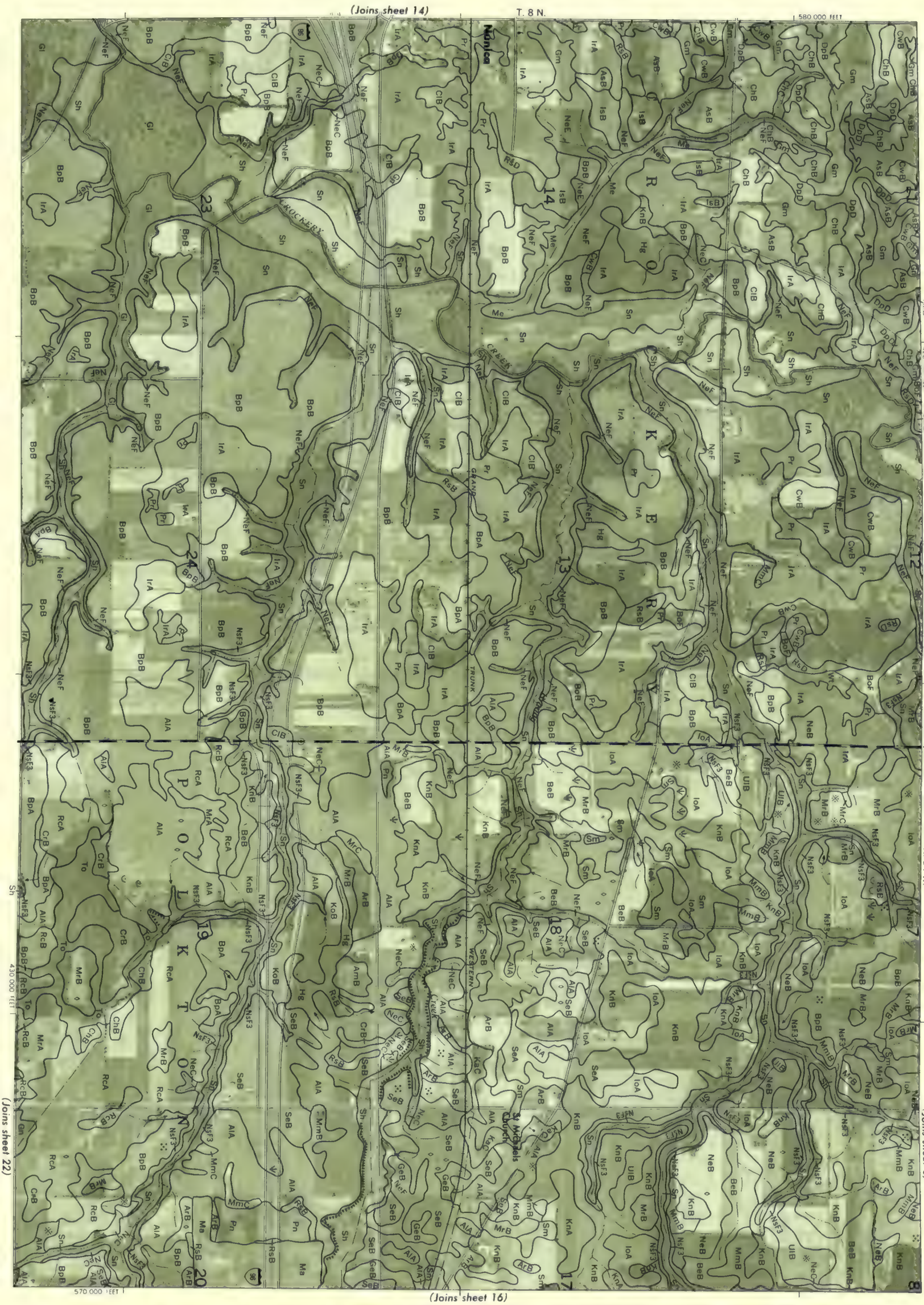
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection: 1927 North American datum·
5,000 foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN NO. 15



1 Mile
5000 4000 3000 2000 1000 0 5000 Feet
Scale 1:15840

N

15

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 16

16

N

435 000 FEET

(Joins sheet 9)

R. 14 W.

T. 8 N.

580 000 FEET

1 Mile

5 000 Feet

Scale 1:15840

(Joins sheet 15)

(Joins sheet 17)

(Joins sheet 23)

450 000 FEET

8 9 10 11 16 17 15 14 21 20 22 23

COOPERSVILLE

COOPERSVILLE CEMETERY

Beaver Creek

Deer Creek

GRAND TRUNK WESTERN

Plane coordinate projection. 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

Land division corners are approximately positioned on this map.

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OTTAWA COUNTY, MICHIGAN NO. 16

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 17

R. 14 W. | R. 13 W.

455 000 FEET

580 000 FEET

T. 8 N.

(Joins sheet 10)

(Joins sheet 16)

(Joins sheet 18)

(Joins sheet 24)

470 000 FEET

POLK TON

WRIGHT

COOPERSVILLE

Wright Church

Penn Central

Grand Trunk Western

Hg Creek

Sand

17

N

1 Mile

5 000 Feet

Scale 1:15840

OTTAWA COUNTY, MICHIGAN NO. 17

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 18

(18)

N

(Joins sheet 11)

R. 13 W.

T. 8 N.

KENT COUNTY

(Joins sheet 17)

(Joins sheet 25)

Miller School

Herrington

WELLS CEMETERY

Sand Creek

PENN CENTRAL

1 Mile

5000 Feet

Scale 1:15840

1 580 040 FEET

485 000 FEET

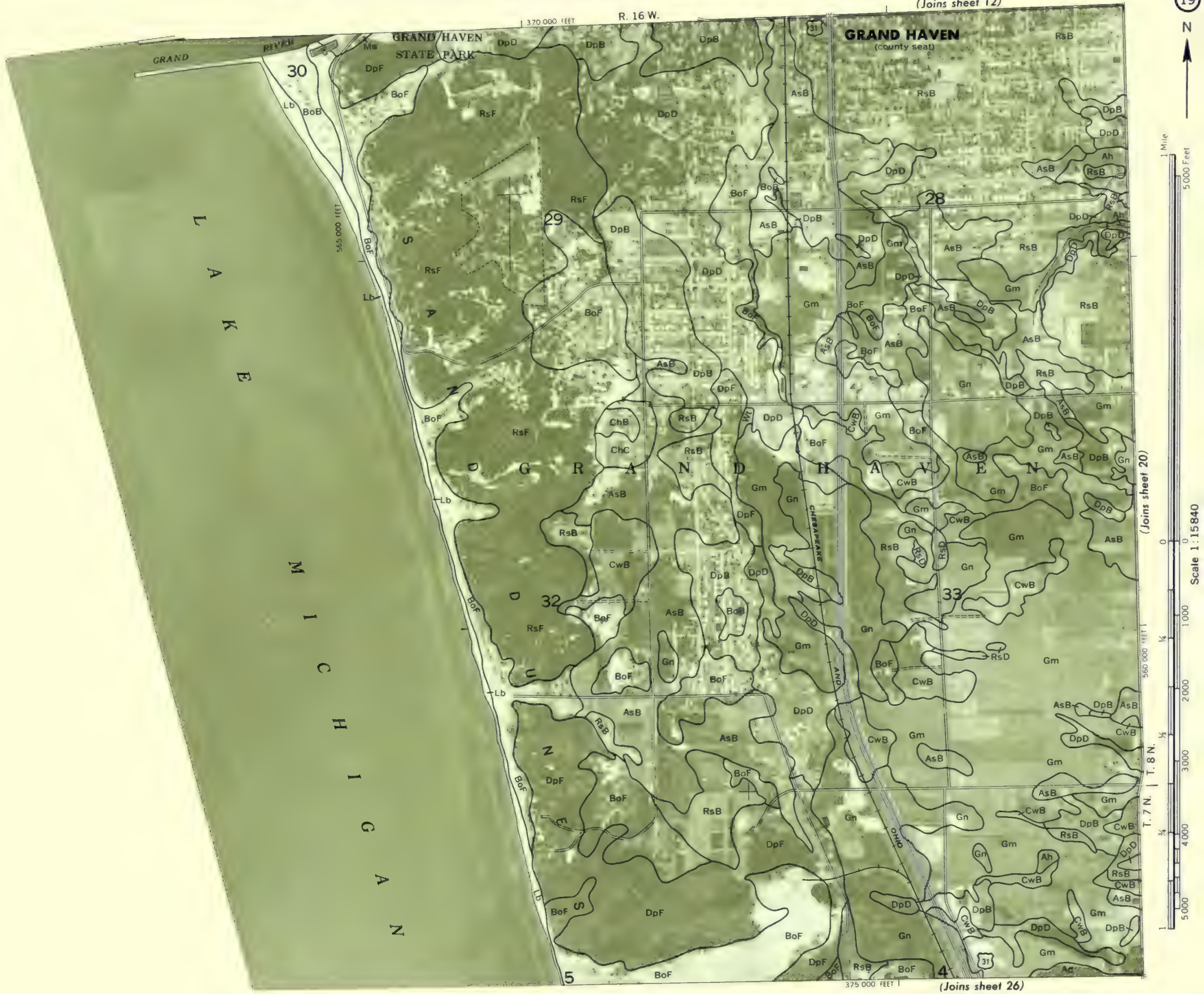
570 000 FEET

OTTAWA COUNTY, MICHIGAN NO. 18

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system
central zone Mosaic compiled from 1968 aerial photographs

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.



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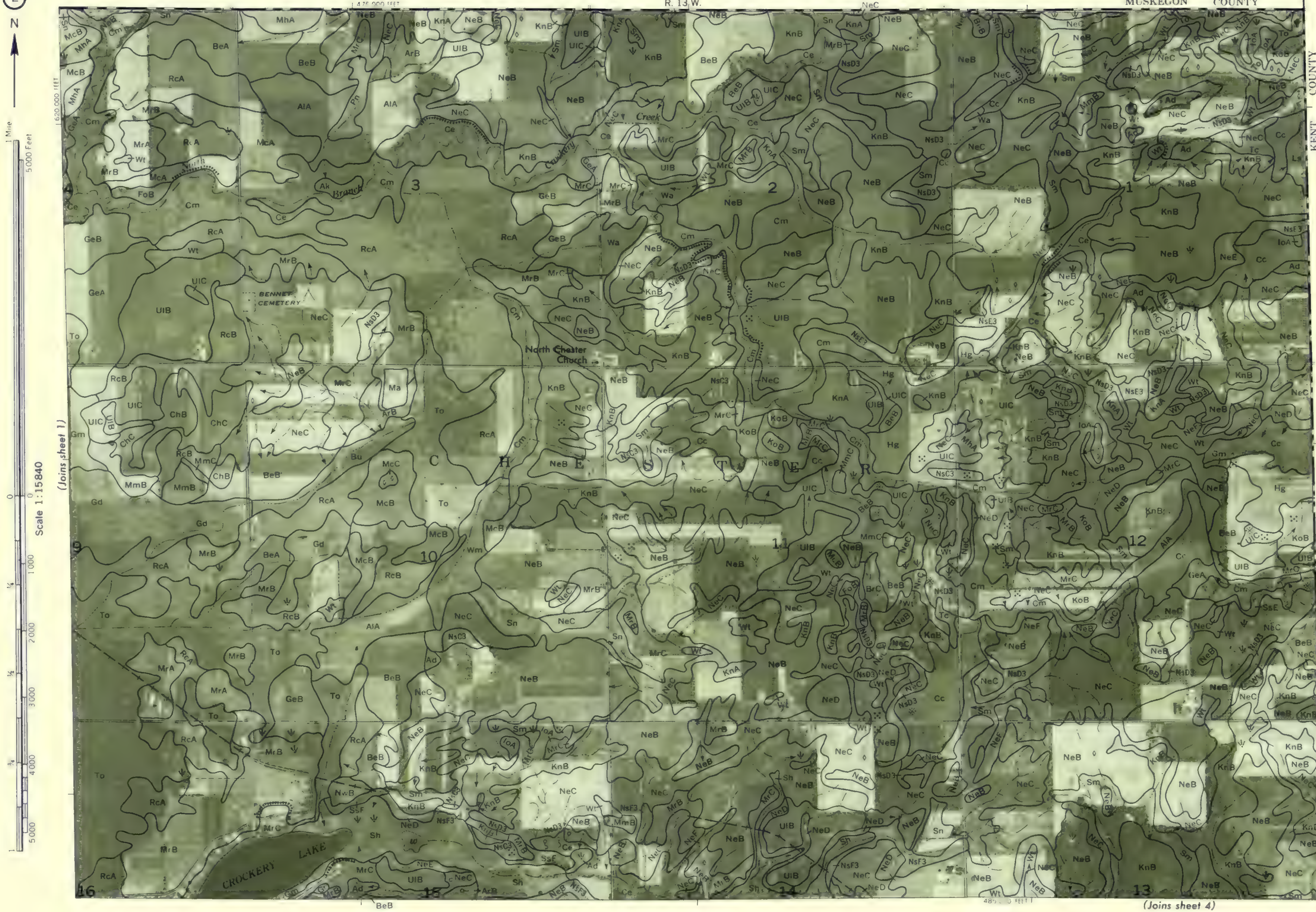
Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 19

Plane coordinate projection, 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 2



OTTAWA COUNTY, MICHIGAN NO. 2

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, centre zone
Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 20

(20)

N

1 Mile

5000 Feet

Scale 1:15840

380 000 FEET

(Joins sheet 13)

R. 16 W. | R. 15 W.

T. 7 N. | T. 8 N.

(Joins sheet 19)

(Joins sheet 21)

(Joins sheet 27)

395 000 FEET

560 000 FEET

465 000 FEET

Nortonville Chapel

Peach Plain School

GRAND RIVER

GRAND HAVEN

LAKE CROCKERY

SPRING LAKE

ROBINSON

Pottawattomie Bayou

Millhouse Bayou

Dermo Bayou

Indian Channel

Stearns Bayou

OTTAWA COUNTY, MICHIGAN NO. 2[illegible]

Land division corners are approximately positioned on this map.

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Plane coordinate projection 1927 North American datum: 5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

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Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 21

Plane coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 22

(Joins sheet 15)

R. 15 W.

R. 14 W.

420 000 FEET

565 000 FEET

560 000 FEET

430 000 FEET

N

1 Mile

5000 Feet

Scale 1:15840

CROCKER

ROBINSON

POKAGON

T. 7 N.

T. 8 N.

26 25 30 29 35 36 31 32 2 1 6 5

Jubb Bayou

GRAND RIVER

South Evergreen School

(Joins sheet 21)

(Joins sheet 23)

(Joins sheet 29)

OTTAWA COUNTY, MICHIGAN NO. 22

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection. 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 23

R. 14 W.

(Joins sheet 16)

COOPERSVILLE

(Joins sheet 22)

(Joins sheet 24)

(Joins sheet 30)

T. 7 N. | T. 8 N.

435 000 FEET

565 000 FEET

500 000 FEET

450 000 FEET

23

N

1 Mile

5 000 Feet

Scale 1:15840

This map is part of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station. Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 23

Plane coordinate projection 1927 North American datum
5 000-foot grid ticks based on Michigan coordinate system central zone Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 24

(24)

N

R. 14 W. | R. 13 W.

455 000 FEET

(Joins sheet 17)

(Joins sheet 23)

(Joins sheet 25)

(Joins sheet 31)

565 000 FEET

560 000 FEET

470 000 FEET

T. 8 N.

T. 7 N.

Scale 1:15840

1 Mile

5000 Feet

1/4 0 1/4 1/2 3/4 1

1000 0 1000 2000 3000 4000 5000

GRAND

PERE MARQUETTE

WESTERN

Little Deer Creek

POLKTON

WRIGHT

GEORGETOWN

25 30 29 28 36 31 32 33 1 6 5 4

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photography

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 25

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 25

(Joins sheet 24)

(Joins sheet 18)

(Joins sheet 32)

R. 13 W.

T. 7 N. | T. 8 N.

1 475 000 FEET

1 565 000 FEET

485 000 FEET

Clayton School

Carroll School

St Marys Church

Manlo

Scale 1:15 840

1 Mile

5000 Feet

KENT COUNTY

Plane coordinate projection. 1927 North American datum.
5,000-foot grid. 1 cm based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

Land division corners are approximately positioned on this map.

This map is one of a set prepared in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Scale 1:15840

1 Mile 0 ½ ¾ 1

5 000 Feet 0 1 000 2 000 3 000 4 000 5 000

N

(26)

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 27

(Joins sheet 20)

380 000 FEET

555 000 FEET

R. 16 W. | R. 15 W.

(Joins sheet 28)

(Joins sheet 26)

(Joins sheet 33)

395 000 FEET

545 000 FEET

T. 7 N.

GRAND HAVEN

Stone School

Bignell School

CHESAPEAKE AND OHIO

CEMETERY

Millhouse Bayou

Stearns Bayou

Scale 1:15840

1 Mile

5,000 Feet

N

27

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN NO. 27

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 28

(28)

N

(Joins sheet 21)

400 000 FEET

R. 15 W.

T. 7 N.

555 000 FEET

Stearns Bayou

R O B I N S O N

(Joins sheet 27)

(Joins sheet 29)

(Joins sheet 34)

415 000 FEET

545 000 FEET

1 Mile

5000 Feet

Scale 1:15840

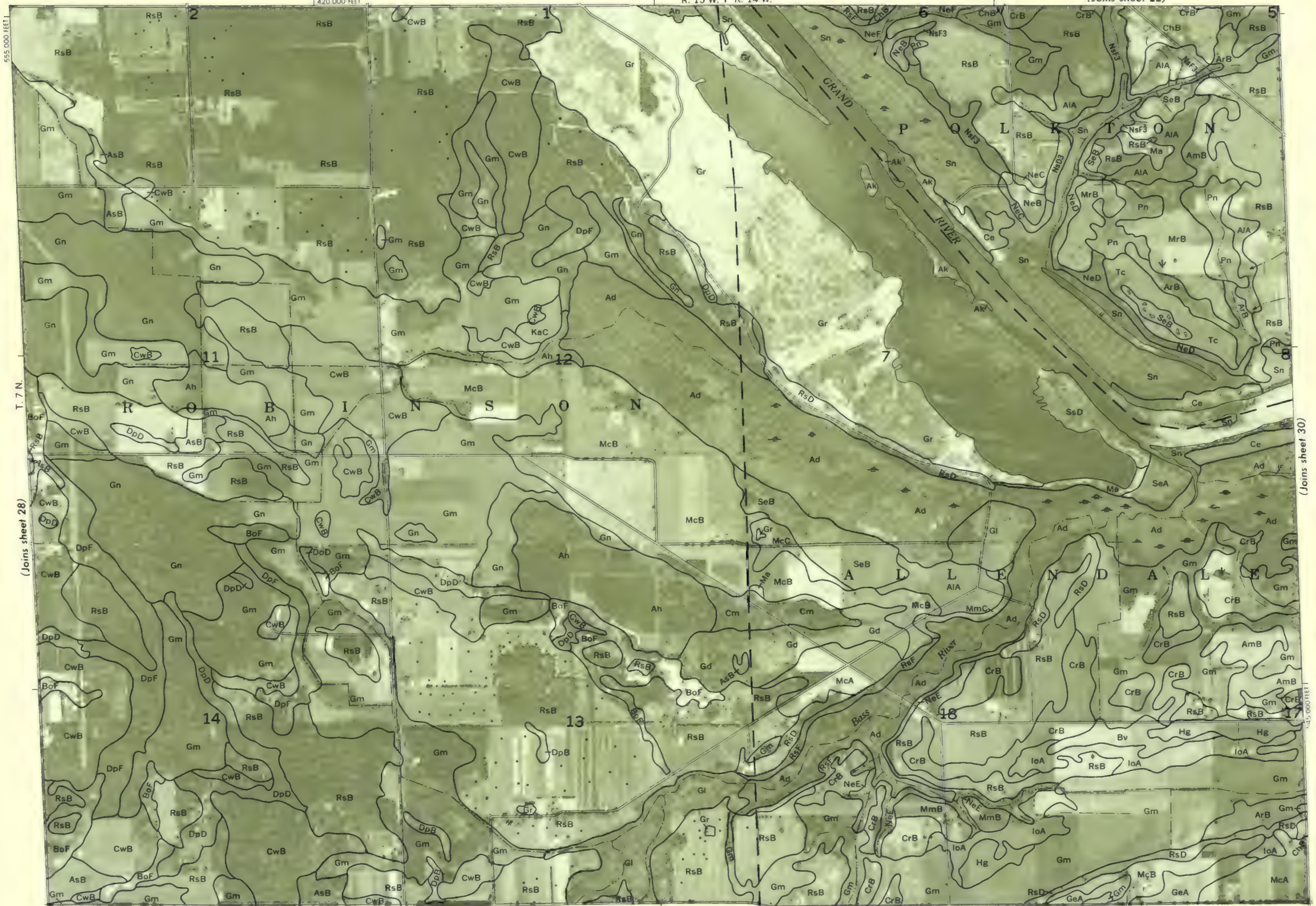
OTTAWA COUNTY, MICHIGAN 28

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection, 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system
central zone. Mosaic compiled from 1968 aerial photographs.

(29)



N

Scale 1:15840

1 Mile

5000 Feet

0 | 1000 | 2000 | 3000 | 4000 | 5000

0 | ¼ | ½ | ¾ | 1

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 29

Plane coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 3

460 000 FEET

R. 13 W.

(Joins sheet 1)

(Joins sheet 4)

(Joins sheet 10)

470 000 FEET

N

1 Mile

5 000 feet

Scale 1:15 840

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection: 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 3

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 30

R. 14 W.

T. 7 N.

(Joins sheet 23)

(Joins sheet 29)

(Joins sheet 31)

(Joins sheet 36)

435 000 FEET

555 000 FEET

545 000 FEET

450 000 FEET

Eastmanville

GRAND RIVER

TOWNSHIP CEMETERY

ALLENDALE

30

N

1 Mile

5,000 Feet

Scale 1:15840

OTTAWA COUNTY, MICHIGAN [illegible]

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system, central zone Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 31

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection: 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN NO. 31

(Joins sheet 25)

475 000 FEET

R. 13 W.

T. 7 N.

555 000 FEET

N

1 Mile

5 000 Feet

Scale 1:15840

0 0 1000 2000 3000 4000 5000

(Joins sheet 31)

(Joins sheet 38)

545 000 FEET

496 000 FEET

KENT COUNTY

OTTAWA COUNTY, MICHIGAN NO. 5

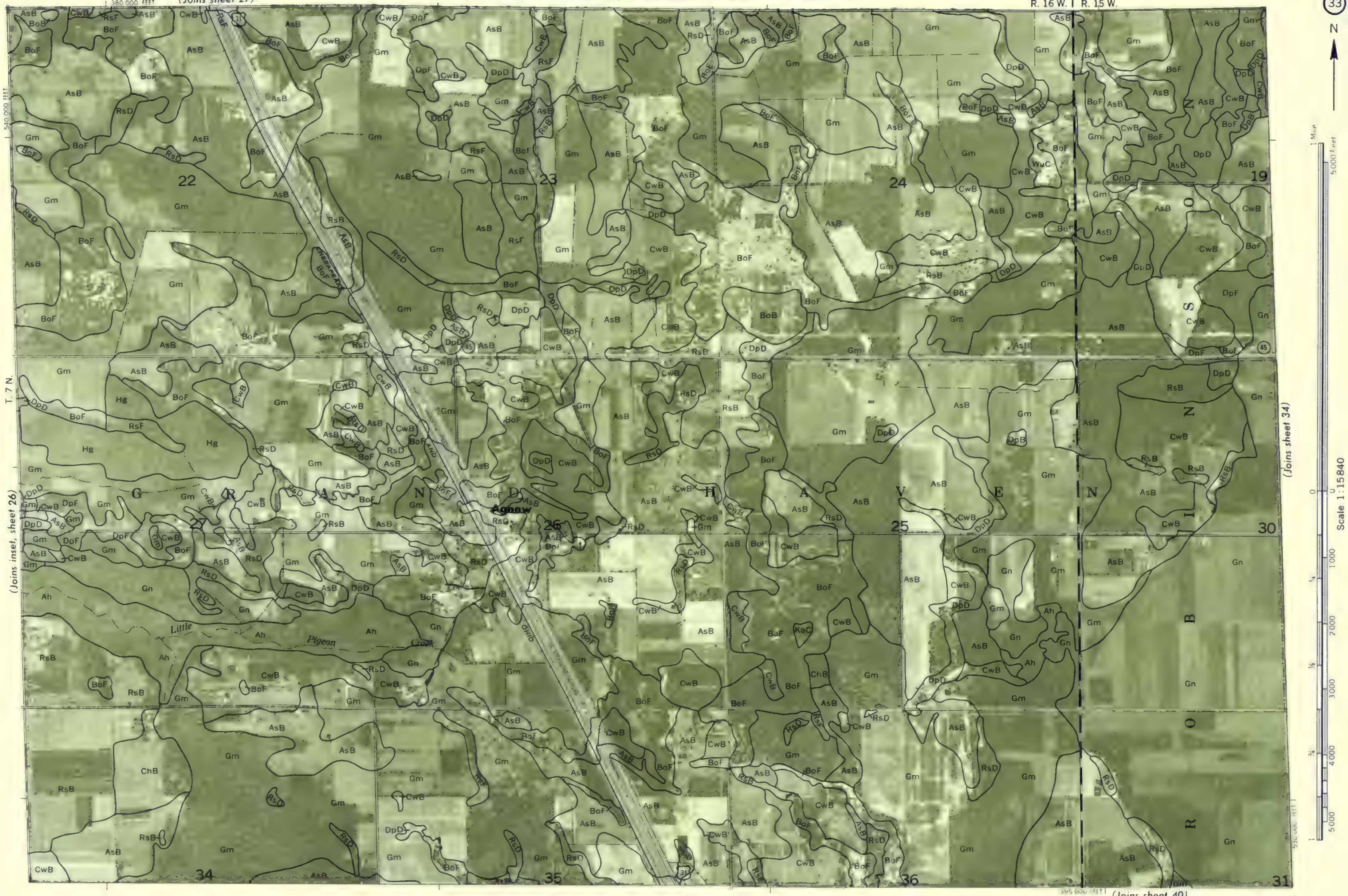
Tallmadge

Wesley Church

Plane coordinate projection. 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.



This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 33

Plane coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system, central zone
Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 34

(34)

N

400 000 FEET

(Joins sheet 28)

R. 15 W.

T. 7 N.

540 000 FEET

1 Mile

5 000 Feet

Scale 1:15840

0 0

¼ 1000

½ 2000

¾ 3000

1 4000

5000

(Joins sheet 33)

R O B I N S O N

19 20 21 22

30 29 28 27

31 32 33 34

(Joins sheet 41)

(Joins sheet 35)

415 000 FEET

OTTAWA COUNTY, MICHIGAN NO. 34

Plane coordinate projection. 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 35

35

N

1 Mile

5,000 Feet

Scale 1:15840

This map is one of a set completed in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 35

(36)

435 000 FEET

(Joins sheet 30) RsB

R. 14 W.

N

1 Mile

5000 Feet

5 040 000 FEET

Scale 1:15840

0 0 1/4 1000 1/2 2000 3/4 4000 1 5000

20 21 22 23

29 28 27 26

32 33 34 35

T. 7 N.

Allendale

Pearline

(Joins sheet 35)

(Joins sheet 43)

(Joins sheet 37)

450 000 FEET

OTTAWA COUNTY, MICHIGAN NO. 36

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection. 1927 North American datum
5 000-foot grid ticks based on Michigan coordinate system central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 37

OTTAWA COUNTY, MICHIGAN NO. 37

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 38

(38)

(Joins sheet 32)

475 000 FEET

R. 13 W.

N

1 Mile

5,000 Feet

540 000 FEET

T. 7 N.

(Joins sheet 37)

Scale 1:15840

0 0 ¼ ½ ¾ 1

1000 2000 3000 4000 5000

21 22 23 24 25 26 27 28 33 34 35 36

A M A N L A K E

LAKE MACATAWA

PARK BOUNDARY

CAMP SHEHORN

Delaney School

Sand Creek School

FENNESSY LAKE

STAFFORD LAKE

ROSEDALE MEMORIAL CEMETERY

Clark

(Joins sheet 45)

490 000 FEET

OTTAWA COUNTY, MICHIGAN NO. 38

KENT COUNTY

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 39

1 Mile
5000 Feet
Scale 1:15840

N

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 39

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 4

(Joins sheet 2)

(Joins sheet 3)

(Joins sheet 11)

R 13 W.

T. 9 N.

Scale 1:15840

1 Mile

5000 Feet

485 000 FEET

OTTAWA COUNTY, MICHIGAN NO. 4

Plane coordinate projection: 1927 North American datum; 5,000-foot grid ticks based on Michigan coordinate system central zone. Mosaic compiled from 1968 aerial photographs.

Land division corners are approximately positioned on this map

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station

(40)

N

1 Mile

5 000 Feet

1 525 000 FEET

1 380 000 FEET (Joins sheet 33)

R. 16 W. | R. 15 W.

T. 6 N. | T. 7 N.

(Joins sheet 39)

(Joins sheet 41)

(Joins sheet 46)

595 000 FEET

520 000 FEET

Scale 1:15840

0 1/4 1/2 3/4 1 — 0 1000 2000 3000 4000 5000

GRAND HAVEN

ROBINSON

PORT SHELDON

OLIVE

West Olive

Pigeon Creek

CHESAPEAKE AND OHIO

CHESAPEAKE

AND

OTTAWA COUNTY, MICHIGAN NO. 4

Land division corners are approximately positioned on this map.

Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the

Plane coordinate projection 1927 North American datum
1,000' tout grid inck, based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 41

41

N

R. 15 W.

400 000 FEET

(Joins sheet 34)

T. 7 N.

T. 6 N.

525 000 FEET

(Joins sheet 40)

(Joins sheet 42)

(Joins sheet 47)

415 000 FEET

520 000 FEET

R O B I N S O N

O L I V E

River

Pigeon

Creek

Sawyer

Sh

ChC

1 Mile

5000 Feet

Scale 1:15840

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station. Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum. 5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN NO. 41

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 42

(42)

N

R. 15 W. | R. 14 W.

T. 7 N.

T. 6 N.

(Joins sheet 35)

(Joins sheet 41)

(Joins sheet 43)

(Joins sheet 48)

1 420 000 FEET

1 525 000 FEET

435 000 FEET

ROBINSON

ALLENDALE

OLIVE

BLENDON

Pigeon River

Bass Creek

Scale 1:15840

1 Mile

5 000 Feet

OTTAWA COUNTY, MICHIGAN NO. 42

Plane coordinate projection: 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system central zone. Mosaic compiled from 1966 aerial photographs.

Land division corners are approximately positioned on this map.

This map is one of a set completed in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 43

R. 14 W.

(Joins sheet 36)

435 000 FEET

525 000 FEET

T. 7 N.

T. 6 N.

(Joins sheet 44)

(Joins sheet 42)

(Joins sheet 49)

450 000 FEET

North Blendon

Bass River

Bass Creek

ALLENDALE

43

N

1 Mile

5000 Feet

Scale 1:15840

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station. Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum 5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 43

(44)

N

1 Mile

5000 Feet

Scale 1:15840

1 455 000 FEET

(Joins sheet 37)

R. 14 W. | R. 13 W.

T. 6 N. | T. 7 N.

ALLENDALE

TALLMADGE

GEORGETOWN

Bauer

Bass Creek

GRAND RIVER

36 31 32 33

1 6 5 4

12 7 8 9

(Joins sheet 43)

(Joins sheet 45)

(Joins sheet 50)

470 000 FEET

OTTAWA COUNTY, MICHIGAN

Land division corners are approximately positioned on this map.

This map is part of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system
central zone Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 45

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 45

Plane coordinate projection 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

45

N

R. 13 W.

T. 6 N. | T. 7 N.

(Joins sheet 38)

(Joins sheet 44)

(Joins sheet 51)

475 000 FEET

525 000 FEET

490 000 FEET

520 000 FEET

GRAND RIVER

FENNESSY LAKE

KENT COUNTY

Georgetown School

River Bend School

HAGER HARDWOOD PARK

Scale 1:15840

1 Mile

5000 Feet

(Joins sheet 40)

380 000 FEET

515 000 FEET

R. 16 W. | R. 15 W.

T. 6 N.

(Joins inset, sheet 39)

(Joins sheet 47)

(Joins sheet 53)

395 000 FEET

PIGEON LAKE

PIGEON RIVER

Ten Hagan Creek

Harlem Church

PORTSHELDON

15 14 13 18 22 23 24 19 27 26 25 30

Gm RsB RsD AsB CwB BoF Ah DpD DpF KaC WuC BoB RsF Gn

Scale 1:15840

1 Mile 5000 Feet

0 0 1000 2000 3000 4000 5000

N

46

OTTAWA COUNTY, MICHIGAN NO. 46

Land division corners are approximately positioned on this map.

Plane coordinate projection: 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 47

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

(48)

N

(Joins sheet 42)

420 000 FEET

R. 15 W.

R. 14 W.

515 000 FEET

T. 6 N.

OTTAWA COUNTY

(Joins sheet 47)

(Joins sheet 49)

Borculo

505 000 FEET

435 000 FEET

(Joins sheet 55)

1 Mile

5000 Feet

Scale 1:15840

OTTAWA COUNTY, MICHIGAN NO. 48

Land division corners are approximately positioned on this map.

Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil

Planar coordinate projection 1927 North American datum
5,000-foot grid ticks based on Michigan coordinate system
central zone Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 49

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection, 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 49

440 000 FEET

515 000 FEET

R. 14 W.

(Joins sheet 43)

T. 6 N.

(Joins sheet 48)

(Joins sheet 50)

505 000 FEET

450 000 FEET

(Joins sheet 56)

South Blendon

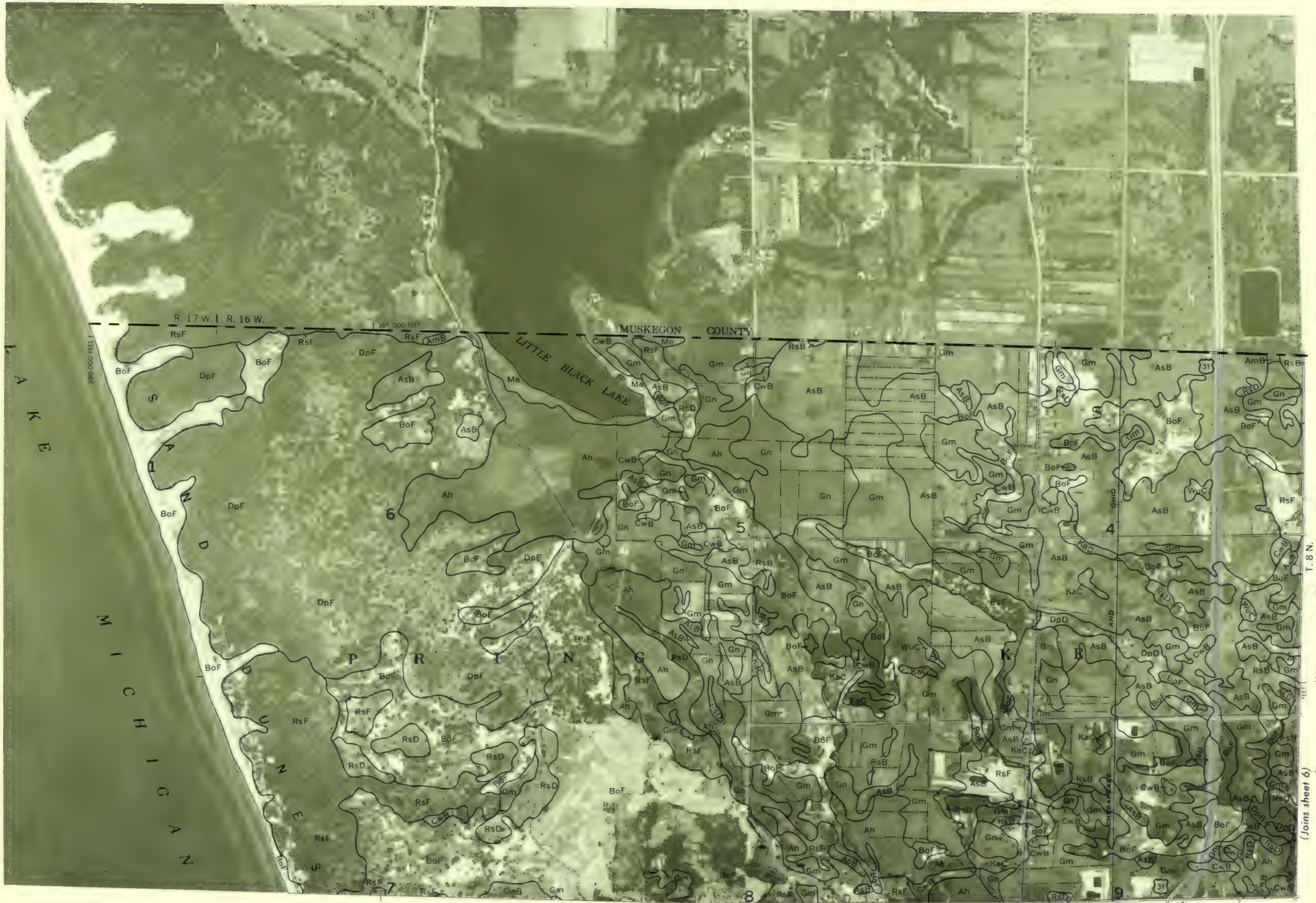
49

N

1 Mile

5000 Feet

Scale 1:15840



This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 5

OTTAWA COUNTY, MICHIGAN NO. 50

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection, 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 51

51

N

1 Mile

5000 Feet

Scale 1:15840

KENT COUNTY

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection: 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

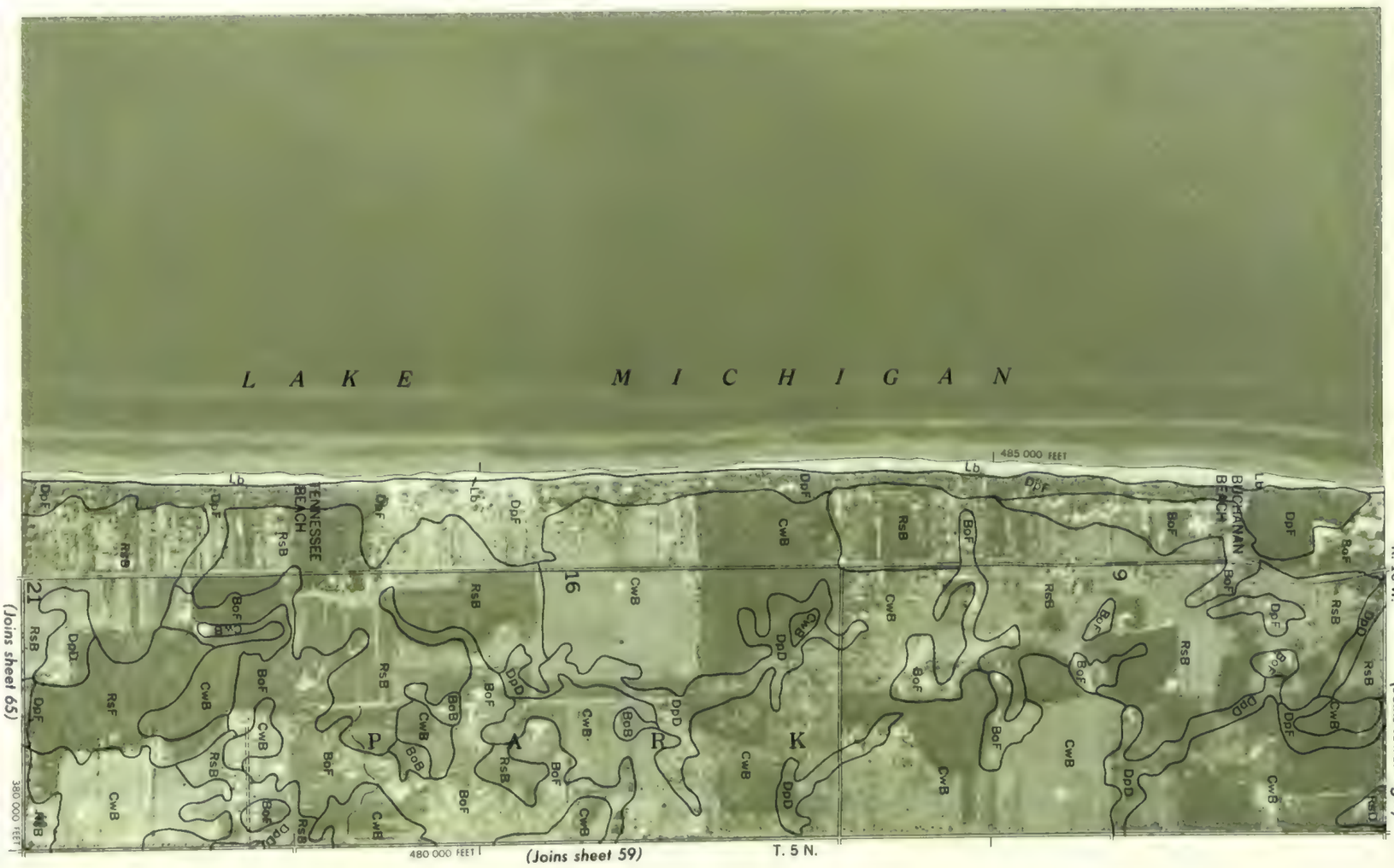
OTTAWA COUNTY, MICHIGAN NO. 51

1 ¾ ½ ¼ 0 1 Mile

5000 4000 3000 2000 1000 0 5000 Feet

Scale 1:15840

N



Plane coordinate projection. 1927 North American datum · 5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 52

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 53

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 54

N

1 Mile

5,000 Feet

Scale 1:15840

(Joins sheet 47)

(Joins sheet 53)

(Joins sheet 55)

(Joins sheet 60)

400 000 FEET

500 000 FEET

490 000 FEET

415 000 FEET

R. 15 W.

T. 6 N.

T. 5 N.

Harlem

New Holland

HOLLAND

CHESAPEAKE AND OHIO

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN — SHEET NO. 54

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN

1 Mile
5000 4000 3000 2000 1000 0 5000 Feet
Scale 1:15840

N

55

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 56

This map is one of a set compiled in 1969 at the ... Department of Agriculture, and the Michigan Agricultural Experiment Station.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN NO. 57

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 57

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 58

OTTAWA COUNTY, MICHIGAN NO. [illegible]

Plane coordinate projection. 1927 North American datum. 5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 59

380 000 FEET

(Joins sheet 53)

R. 16 W. | R. 15 W.

59

N

T. 5 N.

485 000 FEET

480 000 FEET

395 000 FEET

(Joins inset, sheet 52)

(Joins sheet 66)

(Joins sheet 60)

Pine Creek Corners

OAKLAWN BEECHWOOD

Harderwyk Church

Pine Creek

1 Mile

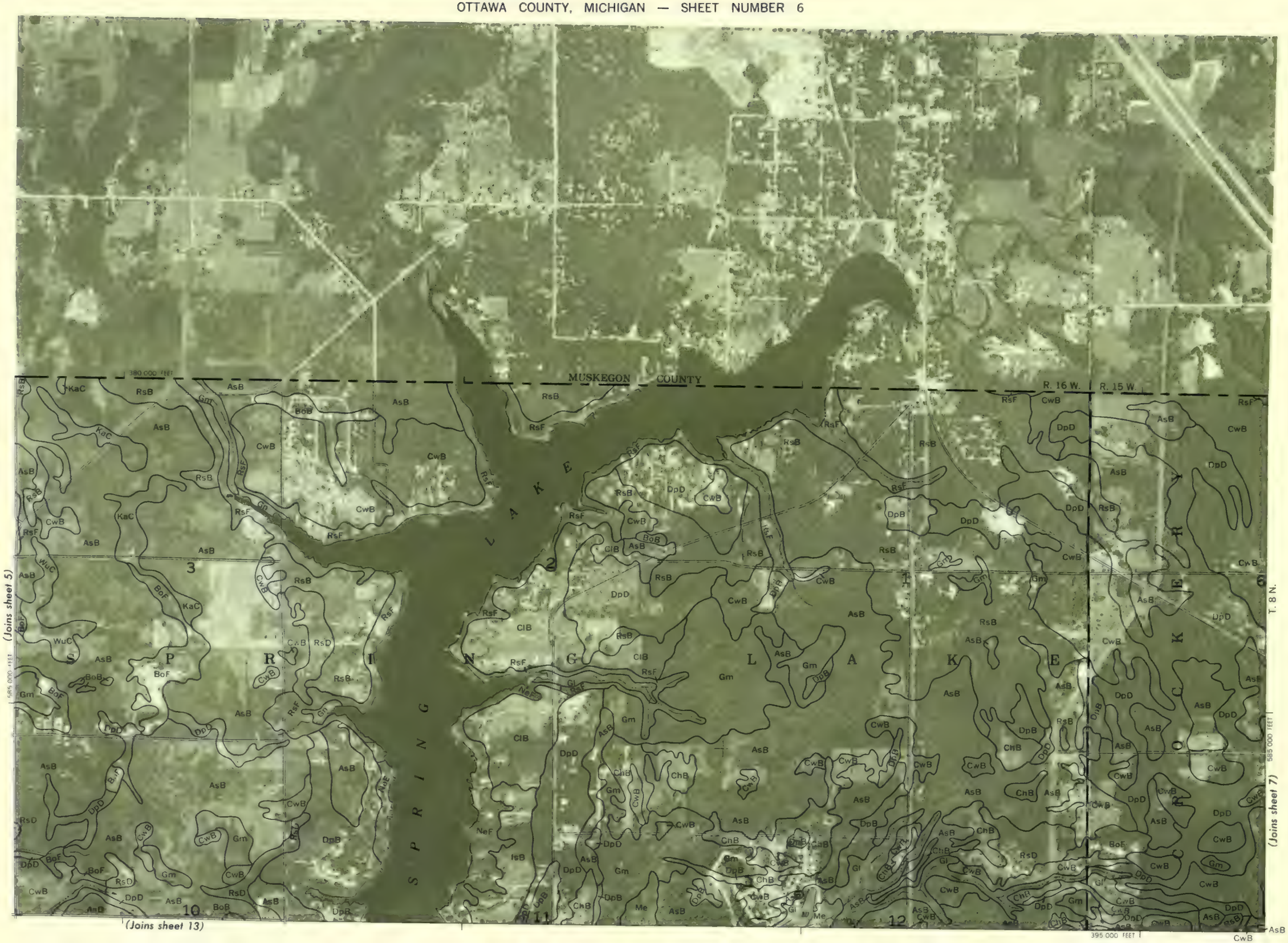
5000 Feet

Scale 1:15840

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN



6

N

1 Mile

5,000 Feet

Scale 1:15840

OTTAWA COUNTY, MICHIGAN NO. 5

Plane coordinate projection, 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

Land division corners are approximately positioned on this map

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 60

60

N

1 Mile 5000 Feet

Scale 1:15840

0 0 1000 2000 3000 4000 5000

1 400 000 FEET

(Joins sheet 54)

R. 15 W.

T. 5 N.

485 000 FEET

480 000 FEET

415 000 FEET

(Joins sheet 59)

(Joins sheet 61)

(Joins sheet 67)

HOLLAND

CHESAPEAKE AND OHIO

Waverly School

7 8 9 10 18 17 16 15 19 20 21 22

OTTAWA COUNTY, MICHIGAN NO. 60

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 61

R. 15 W. | R. 14 W.

(Joins sheet 55)

61

N

T. 5 N.

420 000 FEET

485 000 FEET

(Joins sheet 60)

(Joins sheet 62)

(Joins sheet 68)

ZEELAND

CHESAPEAKE AND OHIO

CEMETERY

1 Mile

5000 Feet

Scale 1:15840

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection. 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN

62

N

(Joins sheet 56)

R. 14 W.

440 000 FEET

485 000 FEET

T. 5 N.

(Joins sheet 61)

(Joins sheet 63)

(Joins sheet 69)

480 000 FEET

456 000 FEET

1 Mile

5 000 Feet

Scale 1:15840

0 1000 2000 3000 4000 5000

OHIO AND CHESAPEAKE RAILROAD

Black River

VRIESLAND CEMETERY

Vriesland

8 9 10 11 16 15 14 17 20 21 22 23

Z E E L A N D

OTTAWA COUNTY, MICHIGAN

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone
Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 63

R. 14 W. | R. 13 W.

T. 5 N.

(Joins sheet 62)

(Joins sheet 57)

(Joins sheet 64)

(Joins sheet 70)

Zutphen

Zutphen School

ZUTPHEN CEMETERY

Forest Grove Station

FOREST GROVE CEMETERY

455 000 FEET

470 000 FEET

480 000 FEET

485 000 FEET

63

N

1 Mile

5000 Feet

Scale 1:15840

OTTAWA COUNTY, MICHIGAN

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 64

(64)

N

(Joins sheet 58)

R. 13 W.

T. 5 N.

(Joins sheet 63)

(Joins sheet 71)

Jamestown

JAMESTOWN CEMETERY

475 000 FEET

485 000 FEET

480 000 FEET

490 000 FEET

1 Mile

5000 Feet

Scale 1:15840

0 1/4 1/2 3/4 1

0 1000 2000 3000 4000 5000

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1958 aerial photographs.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 64

KENT COUNTY

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection: 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 65

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 65

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 66

66

N

1 Mile

5000 Feet

Scale 1:15840

(Joins sheet 65)

(Joins sheet 59)

(Joins sheet 67)

380 000 FEET

475 000 FEET

465 000 FEET

395 000 FEET

R. 16 W.

R. 15.W

T. 5 N.

ALLEGAN COUNTY

Waukazoo School

OTTAWA COUNTY FAIRGROUNDS

Waukazoo Park

Jenison Park

Lake View School

HOLLAND

Big Bayou

Pine Creek Bay

LAKE MACATAWA

PARK TWP

ZEELAND TWP

HOLLAND TWP

22 23 24 19 25 26 27 30 34 35 36 31

RsB CwB DpF DpD BoF Gm Me AsB Gn KaC RsD Ah AmB CrB Ad Sd AlA

OTTAWA COUNTY, MICHIGAN NO. 66

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum:
5,000-foot grid ticks based on Michigan coordinate system, central zone Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 67

R. 15 W.

(Joins sheet 60)

(Joins sheet 66)

(Joins sheet 68)

ALLEGAN COUNTY

T. 5 N.

400 000 FEET

475 000 FEET

415 000 FEET

LAKE MACATAWA

HOLLAND

Beechwood School

Van Raalte School

CEMETERY

BLACK RIVER

CHESAPEAKE AND OHIO

Scale 1:15840

1 Mile

5000 Feet

N

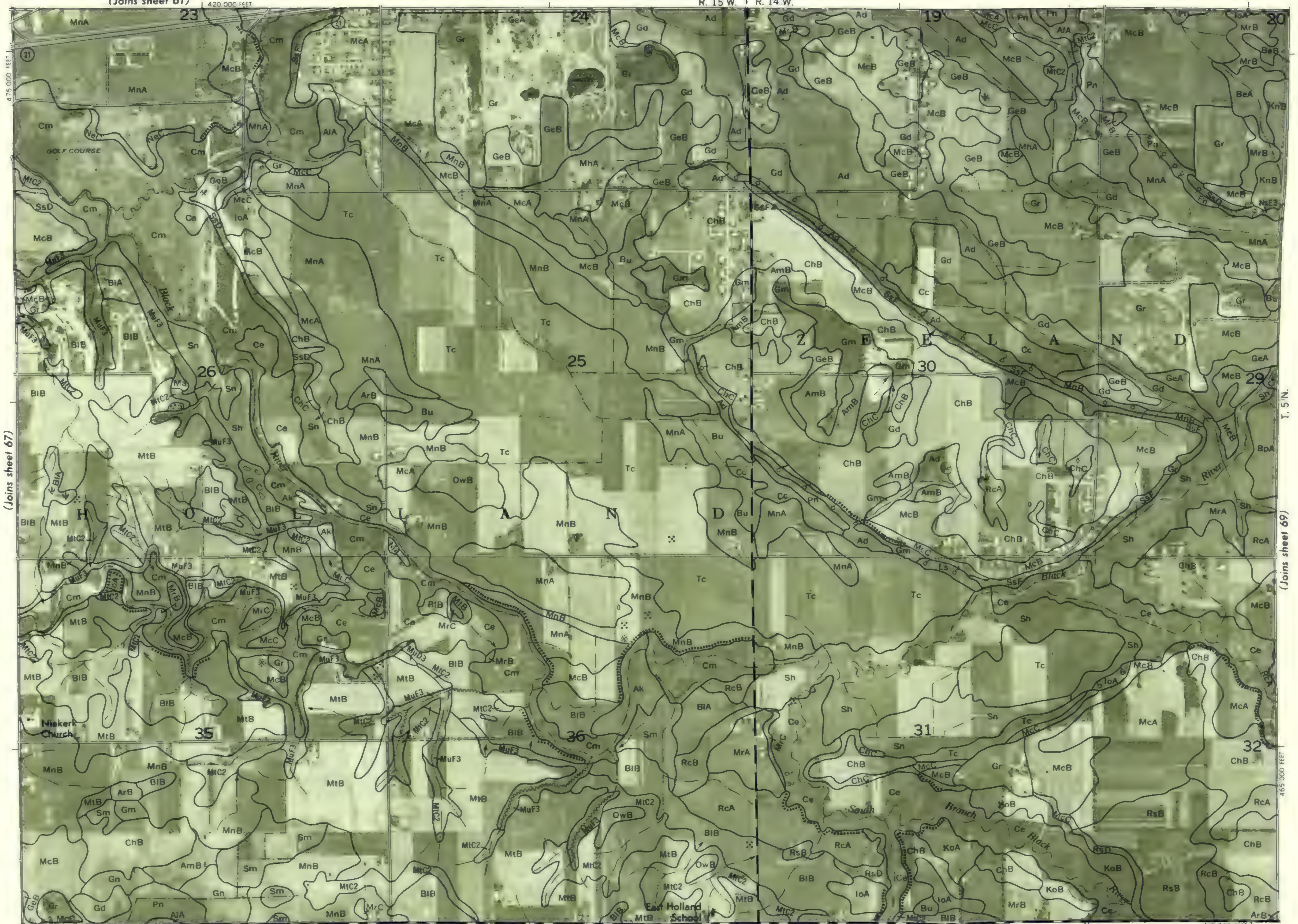
67

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection, 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 67

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 68



N

1 Mile

5000 Feet

Scale 1:15 840

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs

OTTAWA COUNTY, MICHIGAN NO. 68

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 69

69

N

(Joins sheet 62)

(Joins sheet 68)

(Joins sheet 70)

ALLEGAN COUNTY

T. 5 N.

R. 14 W.

440 000 FEET

450 000 FEET

465 000 FEET

475 000 FEET

Black River

EAST DRENTHE CEMETERY

Drenthe

Scale 1:15840

1 Mile

5000 Feet

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum.
5,000 foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 69

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection 1927 North American datum
5,000 foot grid ticks based on Michigan coordinate system,
central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN NO. 7

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 7

1 ¾ ½ ¼ 0 1 Mile
5000 4000 3000 2000 1000 0 5000 Feet
Scale 1:15840

N

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 70

(70)

N

455 000 FEET

(Joins sheet 63)

R. 14 W.

R.13 W.

475 000 FEET

1 Mile

5000 Feet

(Joins sheet 69)

Scale 1:15840

0 ¼ ½ ¾ 1

1000 2000 3000 4000 5000

T. 5 N.

Forest Grove

(Joins sheet 71)

465 000 FEET

470 000 FEET

ALLEGAN COUNTY

OTTAWA COUNTY, MICHIGAN NO. 70

Plane coordinate projection. 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 71

OTTAWA COUNTY, MICHIGAN NO. 71

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

Plane coordinate projection. 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

OTTAWA COUNTY, MICHIGAN — SHEET NUMBER 8

OTTAWA COUNTY, MICHIGAN NO. 8

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.

Plane coordinate projection. 1927 North American datum. 5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.

9

N

1 Mile

5000 Feet

Scale 1:15840

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Michigan Agricultural Experiment Station.
Land division corners are approximately positioned on this map.

OTTAWA COUNTY, MICHIGAN NO. 9

Plane coordinate projection, 1927 North American datum.
5,000-foot grid ticks based on Michigan coordinate system, central zone. Mosaic compiled from 1968 aerial photographs.